THE PRACTICAL MAGAZINE WITH THE PROFESSIONAL APPROACH

Elektor Electronics

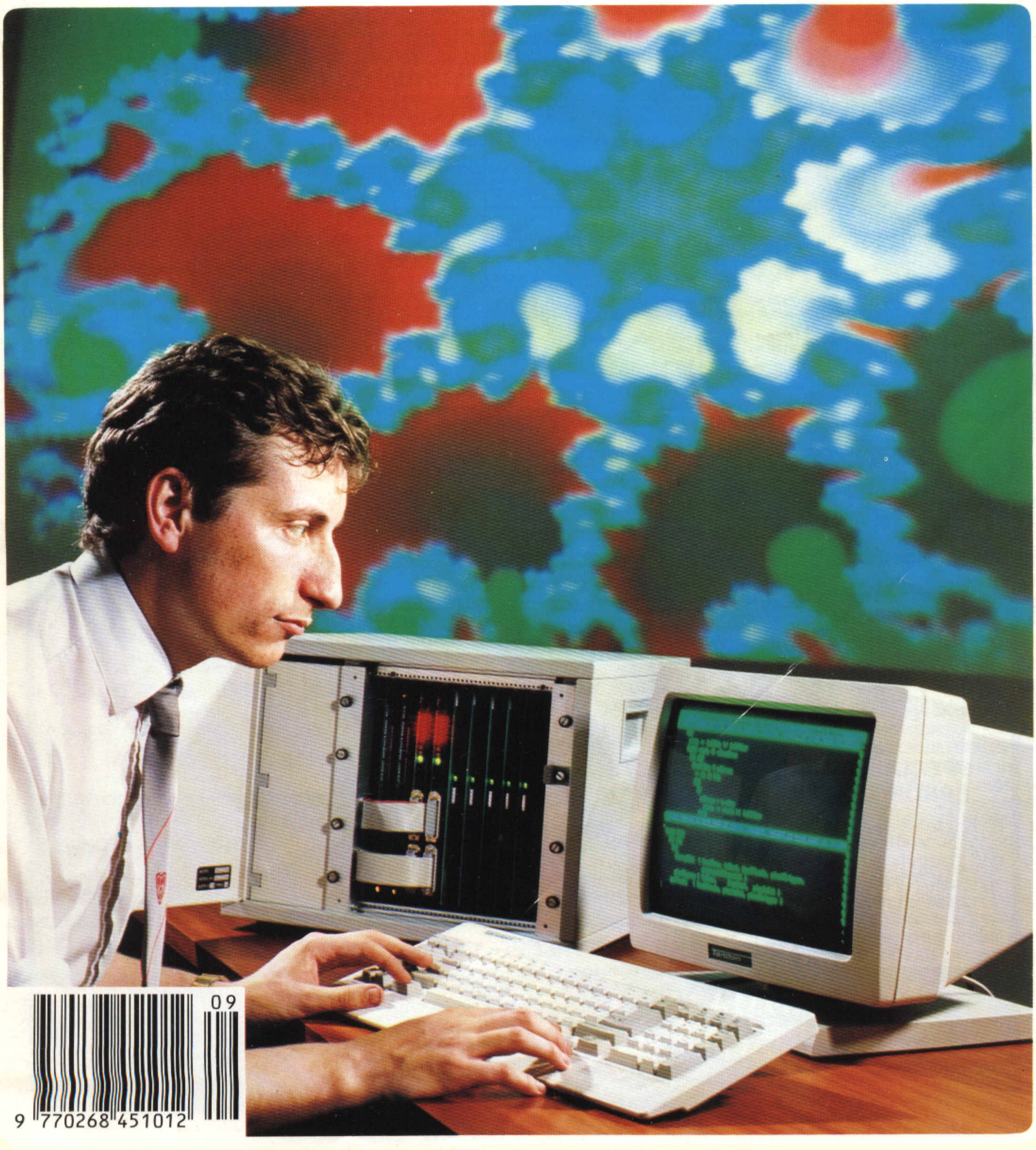
11 ADDRESS 14 24
12 BATTERY 21 CDFAT 28 CAT 29 33 DISH REGS.

September 1988

PCB design on the BBC and PC1512/1640 computers 34 NICAD CHARGER
64 K RAM for MSX NOTE ON TRICKLE RES. 38
DBS Conference 1988 41 BOOK-CHECK
Fast NiCd charger 45 PCB DESIGN
Self-inductance meter 48
55 MERCURY ADDRESS 57 DATA PROTECTION
56 BRIT LIBRARY 58 ERRORS

UK £1·50 IR £2·20 (incl. VAT)

69 COMPUTER TEST CARD 70 SEE P11



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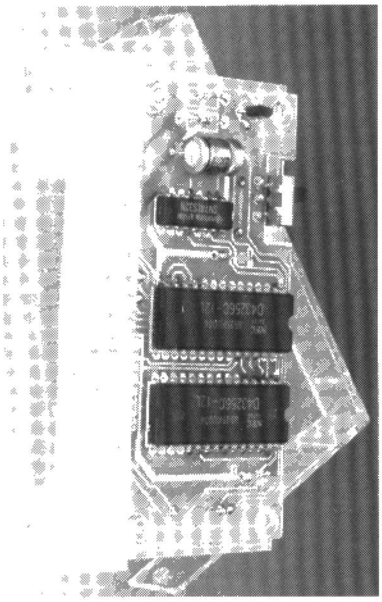
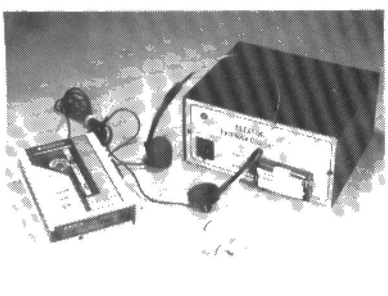
September 1988
Volume 14
Number 159

CONTENTS



64 Kbyte static RAM extension for MSX computers
p. 14

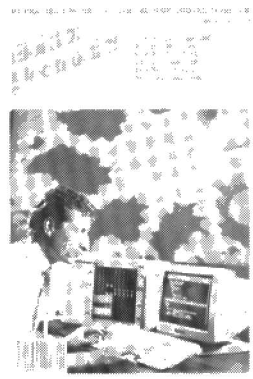
Self-inductance meter
p. 24



Fast NiCd charger
p. 37

In next month's issue:

- MACROVISION decoder
- Programming PALs
- Distance meter
- Preamplifier for purists
- Transistor-curve tracer
- Peripherals for BASIC computer
- Application notes: prescaler SDA 4212



Front cover

A scientist at Bristol Polytechnic's Transputer Centre illustrates the transputer's capabilities in solving the Mandelbrot Set, sometimes described as the most complicated object in mathematics.
Bristol Polytechnic's Transputer Centre has been set up to carry out research and development on uses of the transputer in industry, help companies to exploit the parallel processing potential of the transputer, and to train students and personnel in its use.
One of the new supercomputers, Supernode, developed under the EC's ESPRIT programme by Britain's Thorn EMI and France's Telemat, incorporates 350 transputers and is expected to be on the market shortly at about one tenth the cost of existing supercomputers.

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OPEN SYSTEMS AT CROSSROADS?

When early last year it was announced that a group of major European and American computer manufacturers, the X/Open Group, had agreed to adopt AT&T's UNIX operating system as an industry standard, it seemed that we were at last moving towards an open standard of sorts. But, alas, these intentions are in danger of going the same way as those of the makers of MSX machines: to Never Never Land.

A number of the X/Open Group participants, among them IBM, DEC, Siemens, and Honeywell Bull, have accused AT&T of attempting to influence developments in computer hardware by using UNIX as a lever. They also claim that certain computer companies in which AT&T has a stake, particularly Sun Microsystems, are given advance notice and the opportunity of influencing future versions of UNIX.

AT&T, backed by Unisys, the world's second largest computer manufacturer, ICL, and Xerox, says that all it is trying to do is to unify the many different variants of UNIX into one consistent system that will allow all computers running it to be fully interoperational.

While AT&T maintains that it is fully committed to keeping UNIX open and giving all computer manufacturers unbiased access to future versions of UNIX, the dissenting companies claim that they have been refused to lend a hand in the development of UNIX, although Sun is doing so.

This whole rumpus is, of course, about money — lots of money. Dataquest, the US market research organization, estimates that the world computer market will amount to some $ 11 billion by 1992 and to perhaps more than $ 20 billion by the mid-1990s. Already, UNIX has more than five per cent of this market, and this share is likely to grow to over ten per cent by 1992. That would put AT&T in a very strong position to influence hardware development.

Since AT&T has apparently not agreed to grant the dissenting companies the same facilities as Sun, these manufacturers, led by Hewlett Packard and IBM, have set up Open Software Foundation. They claim that this non-profit making organization, in which they have invested hundreds of millions of dollars, is intended to develop a new version of UNIX that will not be under the control of AT&T, but will be truly open.

Although this would seem to indicate (encouragingly for users the world over) that the major manufacturers are converging on an open system that their customers have been clamouring for since the early 1980s, are we right in being optimistic? After all, the X/Open Group is not dead. In fact, IBM has only just joined the 15 manufacturers, including AT&T and Unisys, that participate in this group. So, there are now two powerful groups of major computer manufacturers (seven of whom belong to both groups) whose aim it is to promote UNIX as a common standard. But which UNIX?

Users the world over can only hope that the two groups will be able to bury the hatchet soon and together produce a universal operating system.

64 KBYTE STATIC RAM EXTENSION FOR MSX COMPUTERS

Although the concept of MSX allows the addressing of up to 1 Mbyte of memory, the number of computers that use more than 128 Kbyte is surprisingly low, and ready-made RAM extension modules thin on the ground. We decided to do something about this, and developed a plug-in RAM extension that enables MSX users to increase the total available memory of the computer in steps of 32 or 64 Kbyte.

With a mere 64 Kbyte installed as a standard, and 128 Kbyte available on newer models only, MSX computers do not follow the trend towards the use of vast amounts of system memory. The diagram of Fig. 1 shows the theoretical memory structure of the MSX concept, which was originally designed for 1 Mbyte of addressable memory. In practice, however, there is not a single MSX computer that actually uses all of the available system memory.

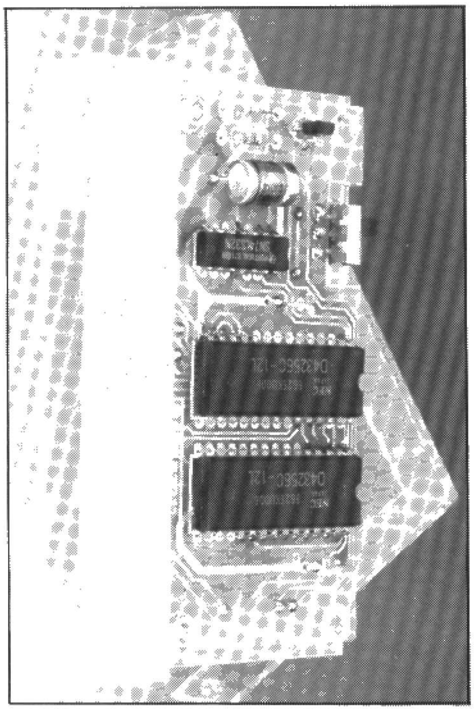
In principle, any MSX computer can have up to four so-called *primary slots*, which are, in turn, subdivided into four blocks of 16 Kbyte. The BASIC and system ROM are located in the address range of the first slot (number 0). The two ROMs use up half the memory in this, occupying address range 0000_H to $7FFF_H$, i.e., two blocks of 32 Kbyte. Random access memory is usually located in another slot, and in address range 8000_H to $FFFF_H$. After a reset, the control system runs a test routine to examine which slots hold RAM.

A slot can be *expanded* with the aid of additional hardware. Slot expansion makes it possible to use four equal banks per slot. Like the slot itself, these banks are in principle composed of four blocks of 16 Kbyte. In practice, a slot expander circuit enables extending the memory capacity of a primary slot from 64 to 256 Kbyte.

Table 1 lists the slot structure of a number of MSX computers, and also shows which slots are expanded internally. The function of the so-called *memory mapper* in MSX-2 machines can be disregarded as far as the present RAM extension card is concerned. Most MSX computers have one or two non-expanded slots, so that 64 or 128 Kbyte of RAM can be added without problems.

More memory, more workspace?

When running in BASIC, MSX computers have relatively little free memory — in practice, this hardly ever amounts to more than 23 Kbyte. It may come as a surprise that adding 128 Kbyte of RAM does not resolve this limitation, since BASIC can not address this additional memory. Does this make any RAM extension useless? Fortunately, the answer is no. Evidently, the present circuit would not have been developed if the computer could not benefit from it. There are programs capable of using the extra memory by bypassing the memory handling routines in MSX BASIC. Still other programs can only work when additional memory is installed, and the above limitations of BASIC are, of course, unknown when machine code is used.



In a number of cases, the RAM extension card described makes it possible to run older programs on more recently introduced computers. This is because the first releases of some programs did not assume that the 64 Kbyte of memory was divided over several slots. This, however, is not strictly required according to the MSX standard. In the case of the present RAM extension, this rule is, of course, observed.

In BASIC, the extension card offers an interesting feature by allowing memory to be made 'read-only' for testing whether a machine code or BASIC program can run from EPROM. Programs developed by the user and intended for storing in EPROM can, therefore, be tested in RAM, obviating the need to clear and load EPROMs for every minor change in the program (an EPROM programmer for MSX computers was described in [1]).

Because the internal memory is nearly always in a 'high' slot number, the control system does not encounter it until all other slots have been examined for the presence of RAM. The control system uses the first RAM bank found. Testing is done in blocks of 16 Kbyte, i.e., in the areas $C000_H$ through $FFFF_H$, and 8000_H through $BFFF_H$. This means that the 32 Kbyte RAM may be divided over two slots.

When a lower slot is selected, the control system will find the extension card before it finds the internal one, and use it as workspace. When, for example, the internal memory is located in slot 3, the RAM extension can be used in slots 0, 1 and 2. The slot allocation of the internal memory is given in Table 1 for a number of commonly used MSX micros. For a computer not listed, consult the technical reference manual supplied with it. The internal RAM is always selected when it is in slot #0 or #1.

Circuit description

The circuit diagram of the RAM extension card is given in Fig. 2. Composed of only two 32 Kbyte static RAM chips, one CMOS IC, two resistors, three capacitors and one FET, the memory extension could hardly be simpler.

Connector K_1 is formed by the (pretinn-

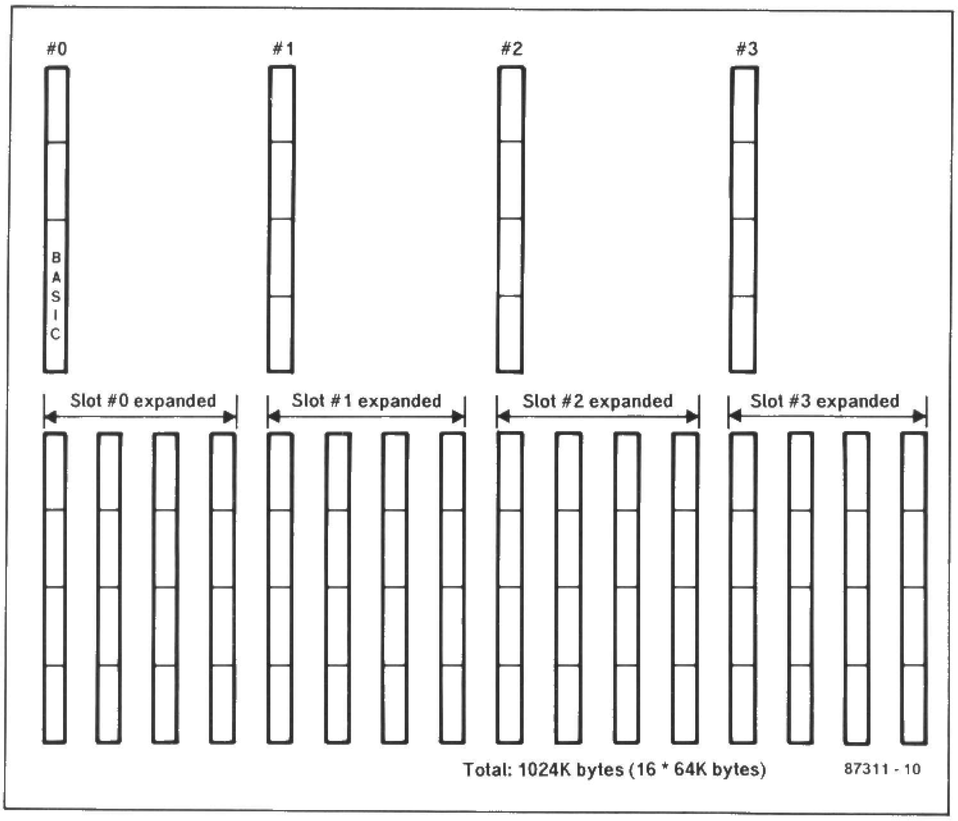


Fig. 1. Theoretical memory structure of MSX computer.

Table 1
Slot assignment of MSX computers

MSX1	RAM-SLOT	REMARKS
AVT Daewoo DPC-200	1	
Canon V20	3	
Goldstrar FC 200	2	
JVC HC-7-gb	2	
Mitsubishi MFL-FX1	3-2	Slot 3 expanded, 64 Kb RAM
Mitsubishi MFL-48	0	32 Kb RAM
Mitsubishi MFL-80	1	
Panasonic CF2700	1	
Philips VG8020	3	
Philips VG8010	0	32 Kb RAM, slot 2 not usable
V68020/20	3-2	
Sanyo MPC-100	3	
Sony HB201p	3	16 Kb ROM firmware in slot 0
Sony HB75p	2	16 Kb ROM firmware in slot 0
Sony HB55p	0	16 Kb RAM, 16 Kb ROM firmware in slot 0
Sony HB10p	3	
Sony HB501p	3	
Spectravideo 738	1	Slot 3 expanded, RS232/Diskrom
Spectravideo 728	1	
Toshiba HX-10	2	
Yamaha CX5M	0	32Kb RAM
Yashica YC-64	3	Slot 1 not usable
MSX2	**RAM-SLOT**	**REMARKS**
AVT Daewoo CPC-300	0-2	Slot 0 expanded. 128 Kb Memory mapper
Sony HB-F500P	0-0 0-2	Slot 0 expanded.
Sony HB-F700P	3-3	Slot 3 expanded. 256 Kb Memory mapper
Sony HB-F900P	0-0 0 -2	Slot 0 expanded. Video digitizer
Sony HB-F9P	3-2	Slot 3 expanded. 128 Kb Memory mapper 16 Kb ROM firmware
Philips VG8220	3-2	Slot 3 expanded. 16 Kb ROM firmware
Philips VG8230	3-2	Slot 3 expanded.
Philips VG8235/8245	3-2	Slot 3 expanded. 128 Kb Memory mapper
Philips VG8250/8255	3-2	Slot 3 expanded. 128 Kb Memory mapper
Philips VG8280	3-2	Slot 3 expanded. 128 Kb Memory mapper Video-digitizer

ed) contact fingers of the double-sided, through-plated, printed circuit board. Gate N_1 combines $\overline{SLTSL}$ and $\overline{MERQ}$ to enable addressing the memory chips. Since these have a capacity of 32 Kbyte each, and $\overline{SLTSL}$ is intended for a range of 64 KByte, the selected address block needs to be divided in two 32 Kbyte blocks. This is accomplished by N_3 and N_4 combining true and inverted signal A15 and $\overline{A15}$ with the output of N_1. Write protect switch S_1 blocks the $\overline{WR}$ signal for both memory chips via gate N_2.

RAMs IC_1 and IC_2 work independently, and one of them may be omitted when only 32 Kbyte of extra RAM is required.

A compact module

The construction of the RAM extension module on PCB Type 87311 is straightforward because the board is through-plated and available ready-made. Before mounting the parts, use a jig-saw to cut off the two corners beside the slot connector along the lines printed on the overlay. Do the same with the area behind S_1.

It is recommended to use good-quality IC sockets for the RAM chips, IC_1 and IC_2. Although the solder resist mask on the ready-made PCB affords protection against excess solder short-circuiting pins or closely running tracks, unexperienced constructors are well advised to work carefully here, and use a low-power soldering iron with a small tip.

Switch S_1 is preferably a miniature slide type that can be fitted securely in the clearance at the rear of the PCB.

A problem may arise with MOSFET T_1. The Type BS170 may be supplied in a different enclosure under the type indication BS170**P**. The **P** version also has a different pin-out — see the circuit diagram. The component overlay of the PCB for the RAM extension is correct for the standard BS170.

Testing

The RAM extension should be tested before it is fitted in an enclosure. Figure 4 shows the listing of a test program typed in under MSX BASIC. The actual test program is machine code loaded as DATA with the aid of a POKE instruction in a FOR/NEXT loop.

Before switching the computer on, close S_1 to turn the extension card into a ROM block. After the computer has finished its initialisation, open S_1, type in or load the test program, and make sure that it addresses the right primary slot, which corresponds to the value POKEd in line 130. It should be noted that the program tests the entire 64 Kbyte space. When the RAM extension functions correctly, the program shows the message MEMORY OK in the top left-hand corner of the screen. When

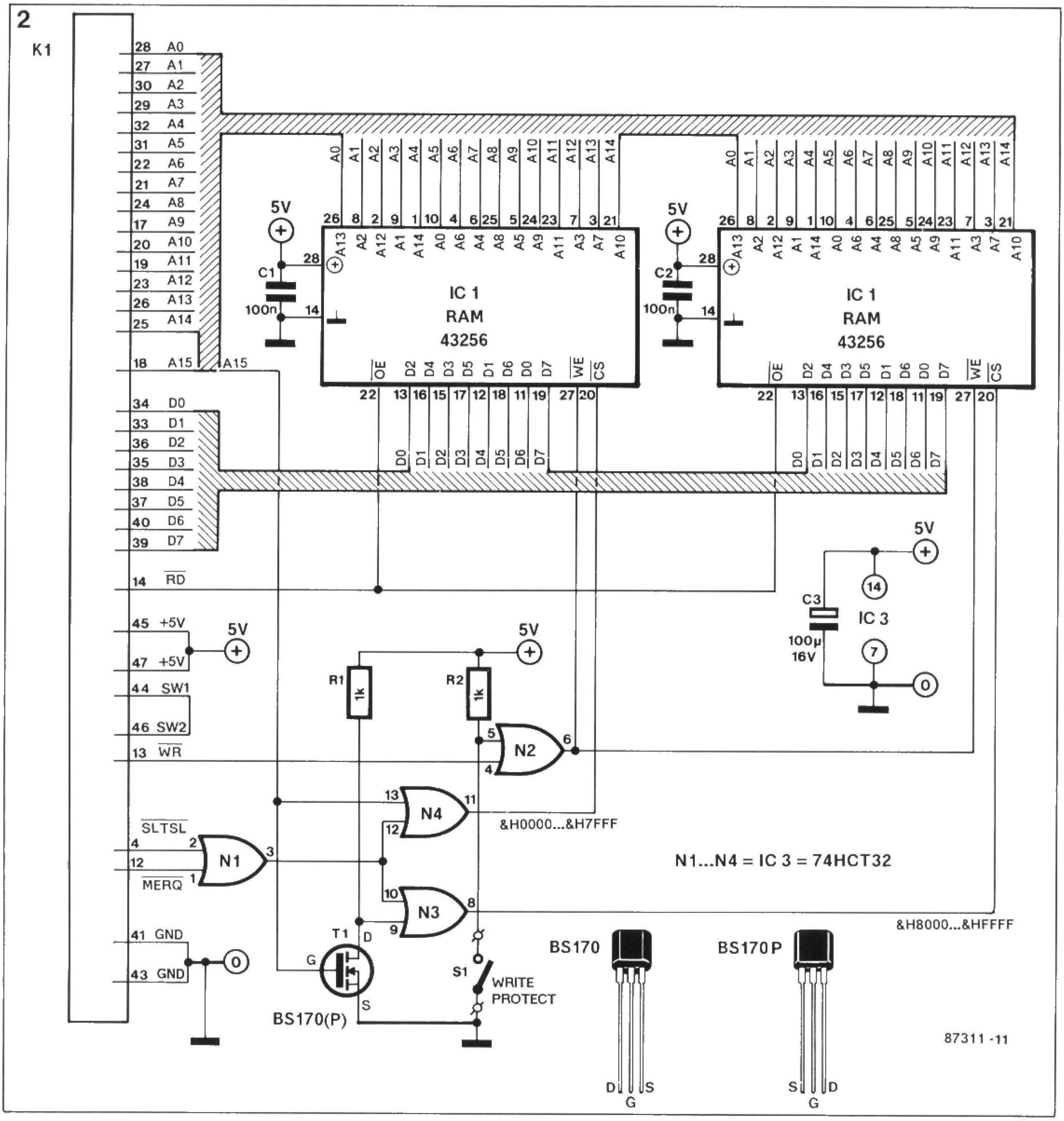


Fig. 2. Circuit diagram of the 32 Kbyte or 64 Kbyte RAM extension for MSX computers.

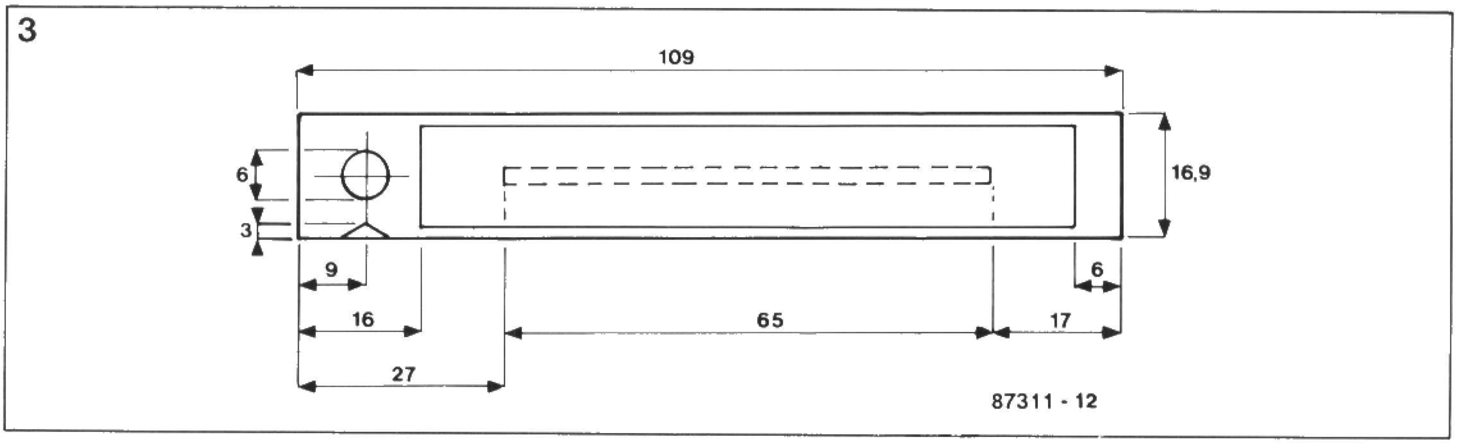


Fig. 3. Cutting and drilling details for the music cassette box.

4

```
10 ' ................          ....... ..................... 64k memory check
20 '
30 '  This program fist writes &H00 to each address from &H0000 to
40 '  &HFFFF. It then checks each address, starting at &H0000, and if
50 '  the byte returned reads &H00, &HFF is written to that address.
60 '  Next, each address is checked again, now starting at &HFFFF,
70 '  and &H00 is written when the address reads &HFF.
80 '  The current memory address is displayed in the top line of the
90 '  screen. The program halts when a faulty address is found.
100 ' The machine code program can be halted by pressing
110 ' keys [CTRL], [SHIFT], [GRAPH] and [CODE] simultaneously.
120 '
130 CLEAR 200,&HB000: POKE &HB170,1 '..... select primary slot number
140 POKE &HFBB0,1: ' .......... enable stop by pressing ctrl-shift-graph-code
150 CLS: LOCATE 7,0: PRINT "Busy "
160 GOSUB 200
170 LOCATE 5,1
180 END
200 RESTORE 330
210 FOR I=0 TO &H16
220   C=0
230   FOR K=0 TO &HF
240     READ A$:B=VAL("&H"+A$)
250     POKE&HB000+I*16+K,B
260     C=C+B
270   NEXT K
280   READ A$:IF C=VAL("&H"+A$)THEN 300
290       PRINT "DATA ERROR IN LINE";320+I*10: END
300 NEXT I
310 DEFUSR0=&HB000: A=USR(0)
320 RETURN
330 DATA 21,0 ,0 ,39,EB,21,0 ,BA, F9,D5,21,0 ,0 ,11,0 ,0 , 420
340 DATA CD,31,B1,3A,70,B1,CD,14, 0 ,2C,20,F1,24,7C,FE,C0, 786
350 DATA 20,EB,CD,31,B1,DB,A8,F5, E6,3F,47,3A,70,B1,CB,F , 8D3
360 DATA CB,F ,B0,F3,D3,A8,3E,0 , 77,F1,D3,A8,FB,2C,20,E2, 942
370 DATA 24,7C,FE,0 ,20,DC,21,0 , 0 ,3A,70,B1,CD,31,B1,CD, 692
380 DATA C ,0 ,FE,0 ,20,3A,11,FF, C ,3A,70,B1,CD,14,0 ,2C, 4DC
390 DATA 20,E7,24,7C,32,FD,AF,FE, C0,20,DE,CD,31,B1,DB,A8, 973
400 DATA F5,E6,3F,47,3A,70,B1,CB, F ,CB,F ,B0,F3,D3,A8,7E, 90C
410 DATA FE,0 ,20,78,3E,FF,77,F1, D3,A8,FB,2C,20,DD,18,2 , 7F4
420 DATA 18,71,24,7C,FE,0 ,20,D3, 21,FF,FF,CD,31,B1,DB,A8, 86B
430 DATA F5,E6,3F,47,3A,70,B1,CB, F ,CB,F ,B0,F3,D3,A8,7E, 90C
440 DATA FE,FF,20,48,3E,0 ,77,F1, D3,A8,FB,2D,20,DD,25,7C, 84C
450 DATA FE,BF,20,D7,21,FF,BF,3A, 70,B1,CD,31,B1,CD,C ,0 , 876
460 DATA FE,FF,20,2F,11,0 ,0 ,3A, 70,B1,CD,14,0 ,2D,7D,FE, 641
470 DATA FF,20,E4,25,7C,FE,FF,20, DE,11,26,B1,21,7 ,0 ,6 , 6B5
480 DATA 9 ,1A,CD,4D,0 ,23,13,5 , 20,F7,18,1A,32,FC,AF,F1, 58F
490 DATA D3,A8,FB,11,19,B1,21,7 , 0 ,6 ,D ,1A,CD,4D,0 ,23, 4E3
500 DATA 13,5 ,20,F7,18,0 ,E1,F9, C9,4D,45,4D,4F,52,59,20, 5E3
510 DATA 4E,4F,54,20,4F,4B,4D,45, 4D,4F,52,59,20,4F,4B,0 , 43E
520 DATA 0 ,C5,D5,E5,F5,22,2F,B1, 21,2F,B1,11,5 ,0 ,3E,0 , 5CB
530 DATA 6 ,1 ,E ,1 ,ED,67,F5,FE, A ,38,2 ,C6,7 ,C6,30,EB, 64F
540 DATA CD,4D,0 ,EB,F1,18,5 ,28, EB,ED,67,23,6 ,1 ,D ,28, 5DC
550 DATA E3,F1,E1,D1,C1,C9,0 ,0 , 0 ,0 ,0 ,0 ,0 ,0 ,0 ,0 , 510
```

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Fig. 4. This program can be used to test the RAM extension card.

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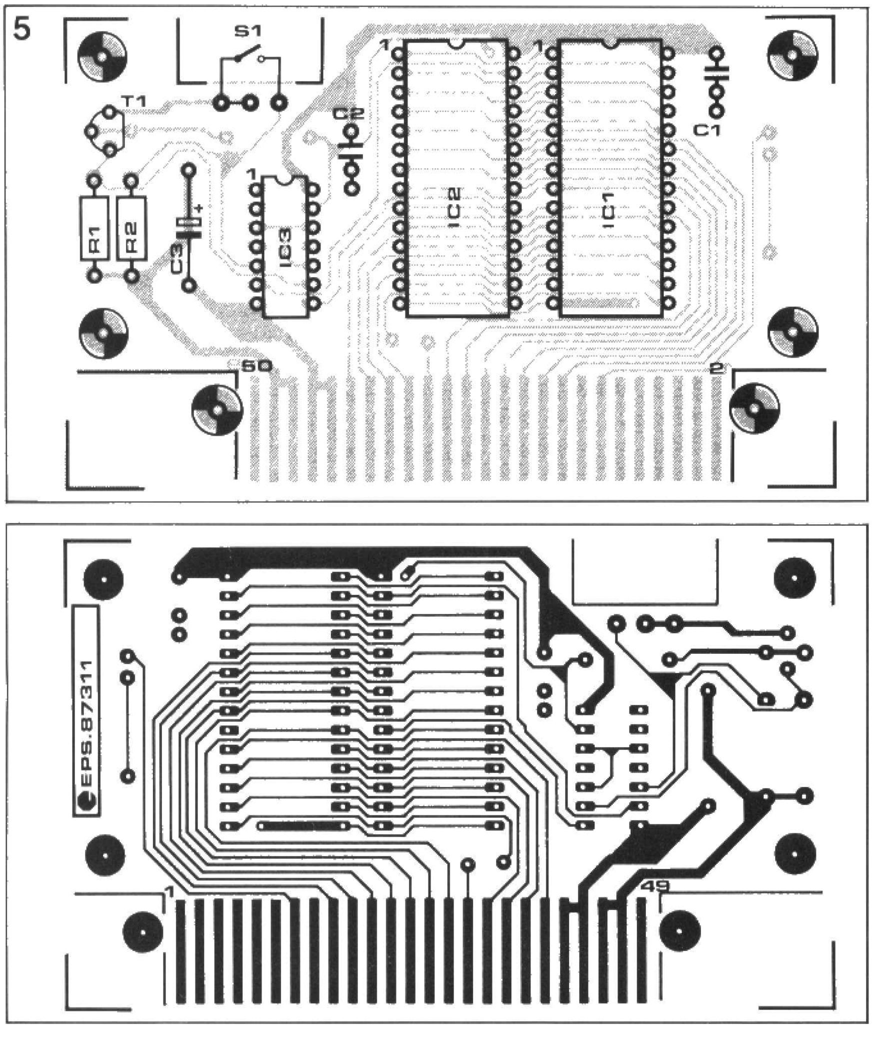


Parts list

Resistors (±5%):
R1;R2 = 1K0

Capacitors:
C1;C2 = 100n
C3 = 100μ; 16 V; axial

Semiconductors:
T1 = BS170 or BS170P (see text)
IC1;IC2 = 43256 or 62256 32K × 8 static RAM (C-I Electonics, Happy Memories)
IC3 = 74HCT32

Miscellaneous:
S1 = miniature slide switch.
PCB Type 87311 (see Readers Services page).

Fig. 5. Component mounting plan of the double-sided, through-plated, printed circuit board for building the RAM extension.

Sony HitBit MSX micro upgraded with 64 Kbyte of random-access memory.

a fault is encountered, it displays MEMORY ERROR in the same location.

Finishing

The completed printed circuit board can be made into a compact and sturdy plug-in module by fitting it in a music cassette box — see the introductory photograph and the drawing of Fig. 3. After removing the lower panel of the box, the PCB is fitted by means of four screws and spacers. After spraying the box with paint, the extension module is ready for use.

Reference:

(1)MSX extensions — 5: EPROM programmer. Part 1: *Elektor Electronics* March 1987; Part 2: *Elektor Electronics* April 1987.

COMPUTER NEWS

Micro-imaging products in Europe

The cross-breeding of computers, laser disks, and microfilm is revolutionizing the storage and retrieval of images, and in Europe alone this will create a $ 243 million annual equipment market in less than five years' time, according to *Analogue and digital micro-imaging in Europe* (#E1009), a look at the emerging technology and issues by Frost & Sullivan.

The national markets of Federal Germany, France, and the UK will each grow to around $ 43 million by 1992.

At present, according to the study, the dominant sectors of the market are WORMs (write once write many times optical disks) at 33% and COM (computer output on microfilm) at 24%. The market will shift dramatically, however, and by 1992 it is forecast that 65% of all expenditure will be on WORMs, and less than 5% on COM.

Frost & Sullivan • Sullivan House • 4 Grosvenor Gardens • LONDON SW1W 0DH • Telex 261671 • FAX +44 1730 3343.

IBM quality award for Salora

One of the few companies that recently received the IBM Supplier Award for 1987 was the Finnish company Salora, a part of the Nokia consumer electronics industry. Salora supplies monitors to IBM's manufacturing plant at Greenock.

The award is given to suppliers in recognition of a highly distinguished level of quality in the materials or service supplied to IBM Greenock. It is part of the company's dynamic quality programme, which is aimed at ensuring 100 per cent customer satisfaction.

Salora Oy • Salorankatu 5-7 • SF-24240 SALO • Finland • Telephone +358 24 3011 • FAX +358 24 18661.

Testing of 80386-based PCBs

Real-time emulation testing of 80386-based PCBs is now available on AQL's Station 20 ATE system. The new support package, called micro MIMIC/386, offers users the ability to test any board based on an Intel 80386 processor, or any PCB that might be processor-dependent such as a PC expansion card, at full real-time speeds. The product's maximum operating rate of 32 MHz is more than adequate to deal with all current speed selections of this popular device. AQL also provides the support package for other members of this processor family, such as the 80286.

Full details from AQL • 16 Cobham Road • Ferndown Industrial Estate • WIMBORNE BH21 7PG • Telephone +44 202 861175 • FAX +44 202 861176.

Supercontroller for CAD

One problem of old-machine-tool users is that of feeding data straight from the CAD station to the machine's control system. Normally, unless a serial interface exists, this is done by producing paper tapes, installing a memory in the machine tool or installing a paper tape emulator.

Each of these solutions presents well-known problems of its own, so Tangram have developped an IBM PC based tool that can act as a 'supercontroller'. It operates by taking NC programs from the main CAE processing system and passing them, at appropriate speeds, to NC machine tools' control panel. Up to 64 machines can be controlled in this way.

For further information, contact Tangram Computer Aided Engineering Ltd • Greyfriars • 2 Eaton Road • COVENTRY CV1 2SB • Telex 31529 • FAX +44 203 552182.

New breed of process control computers.

A new miniature control computer, the Scorpion, with on-board processor, memory, and interfacing, and costing under £ 300, has been announced by Micro-Robotics Ltd.

This general-purpose controller is being used in applications as diverse as marine instrumentation, humidity control in tea drying, and specialist controls in laboratories.

The computer has many different built-in interface ports, including analogue inputs, digital outputs, keyboard and serial interfaces plus LCD, pulse counting inputs, and an I^2C expansion port. In addition, it has 24 K of RAM, a built-in clock/calendar and very low current consumption of 80 mA at 12 V.

A range of expansion modules, priced between £ 15 and£ 50, can be added to the Scorpion to meet exactly a client's requirement.

For further information, contact Micro-Robotics Ltd • 264 Newmarket Road • CAMBRIDGE CB5 8JR • Telephone +44 223 323100.

SCIENCE & TECHNOLOGY BRIEF

Where industry leans on the shoulders of science

by Dr John Geake, Department of Pure and Applied Physics, University of Manchester Institute of Science and Technology

Science parks mushrooming alongside universities reflect the dependence of industry on pure and applied academic work. They have proved the value of often unforseen contributions from scientists working on the frontiers of knowledge. One industrial science group at UMIST (University of Manchester Institute of Science and Technology) has taken this concept into a broader field to provide a consultancy for firms around the world, with an investigative and design service that requires no investment in new buildings and attendant infrastructure. It can call upon the services of more than 100 locally based scientists and reach out to a nationwide pool of expertise.

Modern technology-based industrial companies depend on scientific research for their progress and competitive edge. The big ones have their own research and development departments, of course, and a great deal more work in the UK is carried out in laboratories operated or supported by Government. But it is probably true to say that the bulk of pure research originates in universities. Many firms, especially smaller enterprises that cannot yet afford to support laboratories of their own, may have no scientific staff at all. It is these that need all the help they can get from university sources.

Here there is a problem: universities have other commitments and, although their engineering and technological departments are naturally orientated towards industrial requirements, a large part of the research done in pure science departments may have no obvious direct industrial application. Yet it is from the pure sciences that most fundamental knowledge springs, so industry may have a lot to gain by improving its links with university laboratories. At UMIST we are busy developing a new way of bringing this about.

Science departments of most British universities already undertake industrial work. Some have long and distinguished histories of industrial involvement, while others have only recently found it economically advantageous. Their activities range from individual staff consultancy to running separate, university-owned companies. UMIST, one of Britain's major scientific and technological university institutions, is also the Faculty of Technology of Manchester University, in an important industrial area. It has a long tradition of industrial research, especially into engineering and technological topics, and is now in the forefront of exciting developments in collaboration with industry.

The story began over twelve years ago in UMIST's Physics Department, which pioneered a new type of industrial liaison by forming its Applied Physics Unit (APU). This was an experiment in enlisting pure scientists in the service of industry, by involving the whole of a university science department in industrial consultancy work — probably the first time that this had been attempted other than in wartime. Nearly all of the academic staff of the department agreed to spend a small part of their time on jobs that call for expertise in their own lines of research. I served as the co-ordinator, providing a single entry point for enquiries. I knew the research topics in which my colleagues were involved and was usually able to find someone willing to tackle the job. When the APU did not have the relevant expertise, it was usually possible to find someone elsewhere in UMIST, or even outside, who was able to solve the problem; this was done as a service, so as not to disappoint the client.

Since it started, late in 1974, the APU has carried out more than 180 jobs for over 100 clients and has established a strong reputation, especially in the field of optical and electronic instrument design. We are listed by the UK Design Council as consultants under the Government's Department of Trade and Industry Support for Design Scheme, and have been undertaking design projects under its provisions.

Tne concept pioneered by the physics-based APU has now been greatly extended to include other disciplines by our forming a new organisation called the Industrial Science Group (ISG). Experience with the APU showed clearly that expertise in pure physics could often provide the solutions to practical industrial problems. It therefore seemed likely that the same would apply to the other pure sciences and that it would be very useful to be able to bring together, on certain problems, scientists from different disciplines. This new idea is now gathering momentum. Initially, a group of about 80 academic staff was assembled, with expertise in physics, chemistry, mathematics and electrical science. These were all people who had agreed to be approached when problems came in that seemed to require their particular scientific expertise, and who were willing to form part of a multidisciplinary team. However, when the first jobs were undertaken it became necessary to involve other specialists from the technological and engineering departments, and the group now numbers over 100 academic staff in 13 departments. It

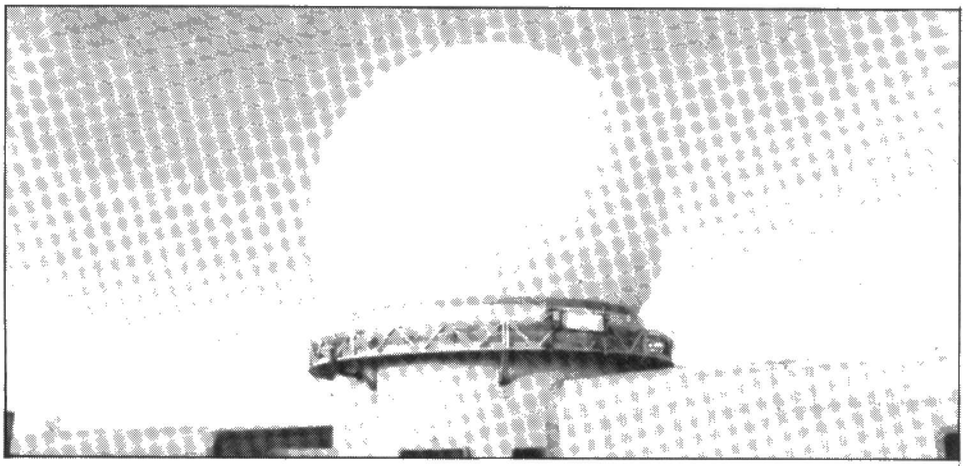
soon became obvious that it was essential to be able to call upon engineering and technological expertise, even when the jobs were mainly based on pure science, to bring about an industrially practicable solution as efficiently as possible.

Including as it now does 15 Professors and 34 Readers and Senior Lecturers, the ISG consultancy team represents a powerful concentration of scientific expertise covering a remarkably wide range of subjects. It is probably the first time that such a group has been placed at the disposal of industry. In spite of its highly academic nature, it is already demonstrating to clients that it can solve down-to-earth industrial problems in a practical way.

Jobs undertaken so far range from one-day consultancies to major programmes, one of which already involves seven consultants from three departments. It has been necessary to learn certain administrative lessons: the ISG was started with a few preliminary ideas as to the types of job we would get, but most of the jobs that have come to us so far have had unexpected features, so administrative flexibility is essential; this means that the structure and operating system of the ISG are continually evolving. Practical operation and analysis are performed on a microcomputer, with specially written software based on a spread-sheet. There is a novel self-checking accounts system and we have a financial future-projection program. All money is handled by the UMIST Bursar, who has approved a scale of fees and income distribution: staff consultants time is reckoned by the day, while overheads are paid to UMIST and to the consultants' departments. The ISG is guided by a management comittee of UMIST staff, with a senior industrialist as chairman.

When an enquiry is received from a client the first step is usually to arrange a meeting, perhaps at UMIST, between the client and the potential consultants. At this meeting, which is free of charge and in complete confidence, we aim to find out whether we can help and, if so, to define the problem and decide which consultants can provide the necessary expertise. Next, a simple standard agreement is completed, setting out the work to be done, and a firm quotation for the consultancy fees is given. A charge for hardware and expenses is assessed when the job has been completed, at cost plus a handling charge; a rough estimate of these factors accompanies the quotation. The job gets under way with the minimum of formality.

After only 18 months in operation the ISG now has 34 jobs completed or in progress, involving 28 consultants from eleven departments. This rapid take-off illustrates industry's need for the type of service we offer and the willingness of academic staff to devote part of their time to such work. But let us look at some examples of the type of job undertaken.



The UK Civil Aviation Authority's radome on Great Dun Fell in northwestern England. Manchester's ISG was commissioned to investigate ways of preventing ice forming on its surface in one of the world's worst combinations of high-humidity, strong winds and sub-zero temperatures.

Our biggest job so far is for the British Civil Aviation Authority. The new radar installation on Great Dun Fell in northwestern England has a potential problem with ice formation on its radome. The ice can absorb radio waves and change their phase, and lumps of it can fall off and cause damage. The ISG was called in to study ways of preventing ice formation and our consultants investigated various forms of heating, as well as other techniques to stop ice sticking to the structure.

The CAA installation is on the same hilltop as the research station run by our Physics Department's Atmospheric Physics Group, who chose the site as having about the worst weather in the North of England. It is in cloud for more than 250 days a year, which is just what the research station wants for its study of cloud properties. The CAA chose the same hilltop for quite different reasons, but it is in what is probably one of the world's worst places for ice formation because high humidity, sub-zero temperatures and strong winds combine to produce grotesque pinnacles of ice. Radomes in Arctic regions, where it is much colder and the winds are even worse, do not have this problem because the humidity is lower.

The first part of the project involved consultants in the Department of Physics, Electrical Engineering and Mechanical Engineering, who made measurements on the radome itself and performed laboratory tests and experiments. Some of the tests made use of a large cold room in the Physics Department which allowed conditions of temperature, humidity and wind at the radome surface to be reproduced, so that preventive measures could be tried out under controlled conditions.

The second part is now under way and involves statistical analysis of data from the UK Meteorological Office to predict the probable frequency of serious icing at the radome. This calls on the expertise of our Mathematics Department.

Automatic chemical analyser

Another job in progress is for an American company based in Cambridge, Massachusetts, that makes automatic chemical analysers. Our work on it involves physics, electronics and chemistry, and is being carried out in several stages. The first was a feasibility study of ways of improving an existing instrument. One of our consultants visited the company's factory and we recommended certain modifications, which we have now completed. Tests have shown a great improvement in its performance. The final stage is to design a totally new unit forming part of the instrument and then to construct a working prototype of it.

Yet another job is to make prototypes for industrial evaluation of a new type of linear critical-angle refractometer invented by an ISG consultant.

Other problems tackled by the ISG have included testing circuit board construction, diagnosing moulding faults, advising on distillation techniques, testing a steriliser and diagnosing faults in printing on water-repellent fabrics. A major project now under way is to develop a system for monitoring the performance of an injection moulding plant. It involves specifying and selecting a range of transducers and a microcomputer, and writing all the necessary software for data acquisition and processing.

So far, work undertaken has called for expertise in fluid flow and vapour properties, surface adhesion, thermal properties of materials, the physics of ice, electronics and software design, chemical analysis, and biochemistry. Between them, the ISG consultants cover a comprehensive range of measurement, analysis and important mathematical

techniques, including statistical analysis of production faults. Mathematical modelling is also of growing importance, enabling the designs of potentially hazardous equipment to be tested to destruction on a computer in complete safety.

During the previous twelve years the APU, which now forms the physics component of the ISG, had worked on many jobs in the general area of instrumentation, including optics, electronics, electrostatics, thermal measurement and X-ray analysis. About half of the jobs involved making measurements with existing instruments, on site or at UMIST, and about a quarter were the type of job we like best, where we have to design and build working prototypes of new instruments. It is interesting that about half of the instruments were invented within the Unit, some of them before the industrial problems to which they provided ready-made solutions were brought to our notice.

Benefits from industrial work

Apart from its obvious benefit to the companies whose problems have been solved, our kind of industrial activity is beneficial to the University in several ways: it has an invigorating effect on the staff, who are introduced to intriguing problems to which someone really needs an answer; it must enliven our teaching, for real applications of basic scientific principles hold the interest of the students and illustrate the relevance of what they are being taught. The extra funds that such activity brings in lead to the upgrading of equipment and facilities. Furthermore it is quite possible that a project which starts out as a small industrial job will develop in the long run into a major collaborative research contract, which may in turn be seen to have wider consequences and to be worth establishing as a new line of research in the department concerned. This is all part of the evolutionary process that continually adapts the universities to serve simultaneously the pursuit of knowledge and the needs of the community.

The UMIST experiment is demonstrating the practicability and the advantages of a new type of industrial involvement for a university, in which a large number of the staff spend a small part of their time on industrial work. This is quite different from either specialist units or separate university companies, and it has the big advantage that the range of expertise available is very wide. Moreover the overheads are low, because there are no separate premises and there need be no separate staff, at least initially. So this idea can be tried out, without having to commit financial resources, by any university where there is someone prepared to organise it.

GEN. INTEREST NEWS

Prototyping service

Professional Cable Systems provides prototyping of electronic circuitry in short turn-round times, enabling designers to get on with their designing rather than constructing prototypes. The company uses the BICC-VERO speedwire system for fast and efficient completion of prototypes direct from a circuit diagram.

Typical prices for populated boards are: single Eurocard (100×160 mm) £72.26; IBM board (with interface — 333×97 mm) £125.46.

Unpopulated boards may also be provided: single Eurocard £12.23; S100 board (254×135 mm) £33.34.

Full price lists and further information from Professional Cable Systems • Unit 4B • Chamber Mill • Heron Street • OLDHAM OL8 4LX • Telephone 061-627 1185.

Third shop for Marco Trading

Marco Trading, the mail order, retail and wholesale suppliers of electronic equipment and components, have opened their third retail shop: SUPERTRONICS at 65 Hurst Street, BIRMINGHAM, Telephone 021-666 6504.

SUPERTRONICS is five minutes' walk from New Street Station and Birmingham's main shopping area, and is just across the road from a large car park.

The new shop has over 1000 sq.ft. of sales area. On display are a wide selection of active and passive components, loudspeaker drive units (4 W to 200 W), test equipment, both new and second hand, alarm equipment, video surveillance cameras, and cable. Also available is an on-site audio and video repair service from Marco's resident engineer.

Also on sale in the shop is Marco's latest mail order catalogue, priced at £1.00 (but containing £6.50 worth of credit vouchers).

The shop is open Monday to Saturday from 9 a.m. to 6 p.m., but closed all day Wednesday.

Radio Amateurs Examination Course

The annual RAE course at Paddington College commences at 6.30 p.m. on 13 September. Enrolments take place during the week commencing 5 September between 1 and 4 p.m. and between 6 and 8 p.m. on the 3rd Floor at Paddington College.

Owing to recent ILEA economies, it is likely that this course will be the only ILEA-sponsored RAE course to be held in the whole of the ILEA area during the academic year 1988-89.

The RAE course at Paddington is perhaps rather different from the normal run of RAE courses: not only does it cover the syllabus for the City & Guilds RAE examination, but also makes available college facilities to allow students to carry out practical experiments in the electronic theory covered. The aim of the course is, therefore, to provide not only an Amateur Radio Licence, but also an elementary grounding in electronics. The course is intended for students with no previous experience of radio or electronics. None the less, Paddington College has over the past few years maintained a very creditable RAE pass rate close to 90% of the candidates entered for the examination.

The course tutors are David Peace (G4KKM) and David Hunt (G6MFR). Further information from Paddington College • Paddington Green • LONDON W2 1NB • Telephone 01-402 6221 or from David Peace on 01-892 7585.

ITU Film Library

The ITU has published the 9th edition of the *Catalogue of Films on Telecommunications and Electronics 1988-89*, which gives information on the 230 films/videocassettes kept by the Film Library. The films are arranged in numerical order and each one has a synopsis in English, French, and Spanish.

The films/videocassettes are lent free of charge for non-profit, non-commercial showings to Administrations, universities, professional and training institutes, and other interested bodies anywhere in the world.

Copies of the catalogue and conditions for borrowing the films/videocassettes are available on request from International Telecommunication Union • The Film Library • Place des Nations • CH-1211 GENEVE 20 • Switzerland Telex 421 000 • FAX +41 22 33 72 56.

PCB test and repair service

A comprehensive test and repair service for PCBs has been developed by Swaptronics. A computerized system, using a 'bed of nails' fixture, tests for open-circuit and short-circuit tracks; checks the function, orientation and tolerance of every analogue component; checks the function of all ICs at very high operational frequencies; and tests the operation of the entire board.

Details from Swaptronics • University of Warwick Sciences Park • COVENTRY CV4 7EZ • Telex 312401 • FAX +44 203 410156.

TEST & MEASURING EQUIPMENT

Part 9: Function Generators (3)

by Julian Nolan

Topward Type TFG-8114

Topward of Taiwan manufacture a wide range of test instruments, ranging from AC Millivoltmeters to a 4 ½-digit DMM. The whole range is characterized by its cost effective design and competitive pricing. The TFG-8114 retails at £327, excl. VAT, and includes a digital frequency counter and a sweep generator: it provides a maximum output frequency of 5 MHz. Its facilities include trigger, gate, linear and logarithmic sweeping. Accessories include a probe and a mains lead.

Compared with most other similarly specified instruments, the TFG-8114 is relatively small: 233×80×300 mm (W×H×D). It weighs a mere 2 kg.

The operating voltage may be selected internally between 115 V and 240 V a.c. ±10%. Power consumption is 18 VA. Connection to the mains is via an IEC plug.

An 18-position plastic swivel enables the instrument to be operated at an angle or stacked; the stand can rotate through 360°.

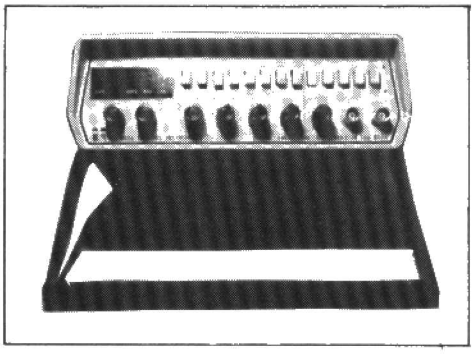
The frequency range is selected unconventionally by two up-down switches rather than the more usual group of push-button switches. This arrangement was, no doubt, dictated by the cramped front panel, which also resulted in the TTL OUT and VCF IN sockets being mounted inconveniently on the rear panel. The up-down switches, although not inconvenient in themselves, cause a slight delay in the time taken in selecting a frequency range as compared with the more usual approach.

The MAIN and FINE controls enable accurate setting of the output frequency. In conjunction with a built-in frequency counter, these uncalibrated controls provide an improvement over the more usual single-course variable control. The output frequency may be varied logarithmically or linearly: in either case its value is displayed by the counter.

The frequency range may be varied from below 0.05 Hz to 5.3 MHz (logarithmic sweep). Some instability is noticeable in this mode at lower frequencies, but this is not the case in the linear sweep mode.

A reasonably effective symmetry control is provided, which enables the duty factor to be increased or decreased by up to 80% and 20% respectively. This also appears to suffer from slight instability at lower frequencies.

None the less, overall frequency stability



is generally good over all ranges.

Two output modes are available: continuous and gated. A manual override is available in the gated mode. Notably, a single-shot facility is not provided.

Risetime on the TTL output is of the order of 10 ns, and on the main output, 45 ns.

In addition to the usual triangular, square and sinusoidal outputs, pulse, ramp and haverwave functions are provided, enabling the generator to provide a really versatile performance. Any errors on most of the waveforms are only visible at the extreme ends of the frequency range.

In the gated mode, the start and stop phase are not variable, which may prove a limiting factor in some operations.

Distortion is fair at <1% from 1 Hz to 100 kHz, but this is perhaps to be expected when the price and facilities offered are taken into account. Distortion remains within reasonable levels up to the maximum output frequency.

The output amplitude is constant over most of the range with only a slight variation of just under 7% visible at the highest multiplier range. The maximum output of 20 V_{pp} into a 1 MΩ load is typical of a generator in this class.

The unit has a −30 dB attenuator, which reduces the minimum output to practically zero, although, owing to relatively small amounts of noise, the 'real' minimum output is about 4 mV_{pp} with, and 15 mV_{pp} without, the attenuator in circuit. Distortion at these levels remains good.

The sweep generator is effective over a range of frequencies with maximum sweep ratios of 1000:1 in the linear mode and 10,000:1 in the logarithmic mode. Start and stop frequencies are variable, and the sweep rate may be varied from 10 ms to 1 s.

The digital frequency counter enables accurate setting of the start and stop frequency parameters, so that reliable sweeping between two known frequencies can be achieved.

Overall, the sweep generator is perhaps the most outstanding feature of the TFG-8114.

Despite the counter's five digits, internal frequency measurement is accurate only up to four digits which, although generally more accurate than the more usual calibrated verniers, is not up to the standard of a typical independent digital frequency counter. Also, the accuracy is restricted at lower frequencies, where long gate times and limited resolution make the advantages of a digital counter less apparent.

The frequency counter may also be driven by an external signal source and this should prove useful in a number of applications.

Sensitivity of the counter is good: 25 mV at 10 MHz to 50 mV at 100 MHz.

Construction of the instrument is based on two epoxy glass PCBs, one housing the counter and power supply circuits, while the other contains the signal generator proper.

The specification and small size of the TFG-8114 result in a dense construction, which may make any necessary servicing rather time-consuming. This will be especially so if access is to be had to the lower (PSU) board.

The small size also has the effect of causing considerable heat dissipation, which is worth bearing in mind if the instrument is to be used continuously for long periods of time.

External construction is based on a two-piece moulded plastic enclosure, which should prove satisfactory in terms of ruggedness in light to medium working conditions. The stand is also of plastic and this may prove to be more susceptible to damage than the enclosure.

Conclusion. Overall, the TFG-8110 represents a good price/performance. The signal source gives a sustained good performance and the frequency counter, although perhaps of limited value for some applications, contributes significantly to the instrument as a whole.

Construction is cramped and this may in some cases cause problems in servicing. The heat dissipation may also be a problem where the instrument is intended for continuous, or near continuous, use.

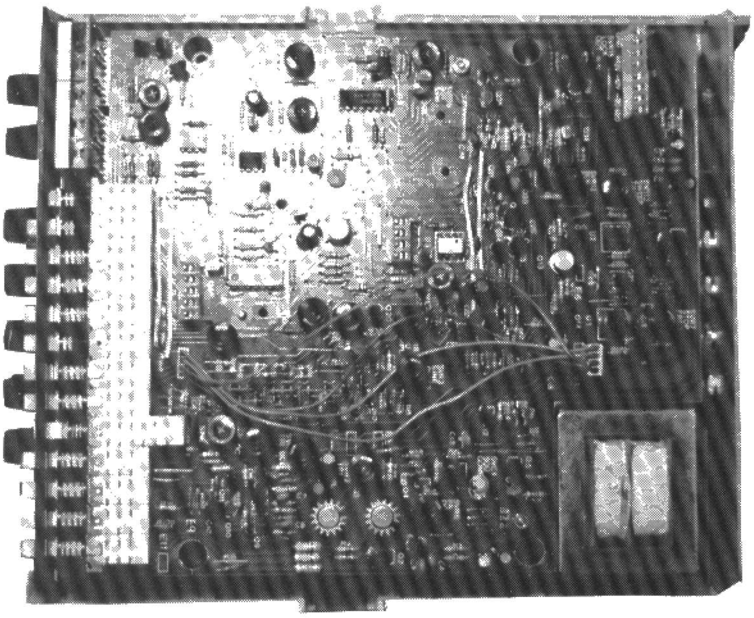


Table 11

OPERATING RANGE

Frequency range: <0.1 Hz to 5 MHz, coarse and fine adjustment possible.
External sweep range: variable over >1000:1 (linear) or >10,000:1 (logarithmic) by 0—5 V d.c. Sweep rate 10 ms to 1 s.
Frequency accuracy — same as counter accuracy.

OPERATING MODES

Sine wave: distortion <1% from 1 Hz to 100 kHz. Over 100 kHz to 5 MHz range all harmonics 24 dB below fundamental.
Triangle linearity: <1% over 1 Hz to 100 kHz.
Rise/fall time: (square wave) <40 ns.
DC range: 10 V_{pp} (50-ohm load).
DC offset: variable ±5 V into 50 ohms.
Trigger/gate: manual or external (TTL compatible).

OUTPUTS

50 Ω: 0—20 V_{pp} from 50 Ω ±10% source. 0—10 V across 50-ohm load. Switched attenuator reduces signal and DC offset by 0 dB or 40 dB. Output short-circuit protected.
TTL: capable of driving up to 20 standard TTL loads.

COUNTER

Range: 10 Hz to 100 MHz.
Gate time: 0.01 s; 0.1 s; 1 s; 10 s.
Accuracy: ±(1 count + timebase accuracy).
Sensitivity: 25 mV_{rms} (10 MHz); 50 mV_{rms} (100 MHz).
Max. voltage: 150 V_{rms} (DC + peak AC)
Attenuator: 0 dB; −30 dB.
Impedance: 1 MΩ/100 pF.
Timebase: 10 MHz ±10 ppm.

GENERAL

Input voltage: 115 V AC or 240 V AC, 50/60 Hz.
Power consumption: 18 VA.
Dimensions: 233×80×300 mm (W×H×D).
Weight: 2 kg.
Accessories supplied: mains lead, manual, connecting cable.
Warranty: 1 year.

Table 12

	Unsatisfactory	Satisfactory	Good	Very good	Excellent
Dial accuracy				NA	
Dial resolution				NA	
External sweep range					x
Distortion				x	
Frequency range					x
Output level range					x
Internal construction			x		
External construction			x		
Overall specification				x	
Ease of use			x		
Manual				x	

The TFG-8114 was supplied by Telonic Instruments Ltd, Boyn Valley Road, MAIDENHEAD SL6 4EG, telephone (0628) 73933.

Other function generators available in the Topward range

TFG-8101 — sine, square, and triangular functions as well as ramp and pulse. Frequency range 0.1—2 MHz. Peak open-circuit output 5 mV_{pp}—2 V_{pp}. Distortion < 1%. TTL output. VCF input. Retail price £115, excl. VAT.

TFG-8104 — same as TFG-8101, but with AM (0—100%) and FM (0—±10%). Retail price £129, excl. VAT.

TFG-8111 — based on TFG-8114, but without sweep, trigger, gate or burst facilities. Frequency range 0—2 MHz. Instead of the TFG-8114's 5-digit frequency counter, the TFG-8111 is provided with a 6-digit unit. Retail price £189, excl. VAT.

TFG-4613 — frequency range 0.1 Hz to 13 MHz. FM and AM. Triggered, gated, sweep, and burst modes. Sweep rates 0.01 Hz to 10 kHz. Variable start/stop phase. Retail price £549, excl. VAT.

TAG-4005 — audio signal generator. Frequency range 5 Hz to 500 kHz. Distortion 0.005%. Comprehensive variable attenuation facilities. Retail price £222, excl. VAT.

SELF-INDUCTANCE METER

Measuring self-inductance reliably is notoriously difficult and inductance meters are, therefore, few and far between and also quite expensive. The instrument described here offers reasonably accurate (within 1%) measuring of low-frequency inductors from 10 μH to 2 H.

One of the reasons that the measurement of inductance is so tricky is that the value of inductance varies considerably with the conditions of measurement. The principal reason for the variation in inductance is the variation of permeability, which changes with the level of the test signal and the d.c. bias.

Principle of meter

When a non-constant current is passed through an inductance, an e.m.f., u, is induced whose magnitude depends on the rate of change of current, di, in a unit of time, dt, i.e.

$$u = L(di/dt).$$

If di/dt is kept constant (=k) by increasing or decreasing the current uniformly,

$$u = Lk$$

that is, the e.m.f. is directly proportional to the inductance (see Fig. 1).

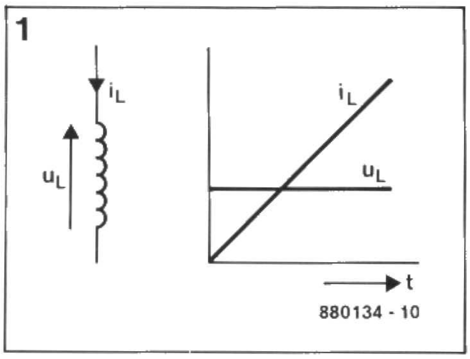


Fig. 1. A uniformly increasing or decreasing current through an inductor causes a constant voltage to be induced across the inductor.

In practice, however, it is impossible to create a uniformly increasing or decreasing current, but a good alternative is a current whose waveform is triangular (see Fig. 2). If such a current is passed through an inductance, the induced e.m.f. will have a rectangular waveform as shown in Fig. 2. If that e.m.f. is rectified, the resulting direct voltage is a measure of the inductance. Unfortunately, no inductance is pure: it always has some internal resistance, R, in series with it. Thus,

$$u = u_L + u_R.$$

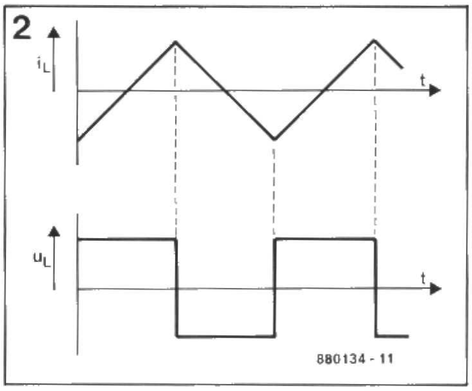


Fig. 2. A triangular current through an inductor causes a rectangular voltage across the inductor.

The three voltages are shown in Fig. 3. Rectification produces a direct voltage with a small sawtooth-shaped ripple, which is caused by u_R. The average value of the direct voltage (shown dashed in Fig. 3d), remains a true indication of the inductance, however.
This shows that in this method of measurement the internal resistance of the inductor (unless it becomes large) does not affect the measurement.

Block schematic

The block diagram of the proposed meter is given in Fig. 4.
The function generator, consisting of a combination of an integrator and a Schmitt trigger, generates a triangular and a rectangular voltage.
The triangular voltage is converted into a triangular current superimposed on a direct current. The composite current, which is thus always greater than 0, is passed through the inductor on test, L_x. Range switching is effected by reducing the current by a factor 10 for each higher measuring range.
The a.c. component of the voltage across L_x is amplified and then applied to the first of three electronic switches, ES_1 to ES_3.
The electronic switches are controlled by the rectangular voltage from the function generator and provide half-wave synchronous rectification of the alternating voltage.
Since this type of rectification halves the average value of the input voltage, the preceding amplifier raises the magnitude of the a.c. component across L_x by a factor 2.
The rectified voltage is applied to a digital voltmeter, DVM, which displays the value of L_x in henrys.

Triangular current

If the DVM has a full-scale deflection, f.s.d., of, say, 200 mV, the input to it

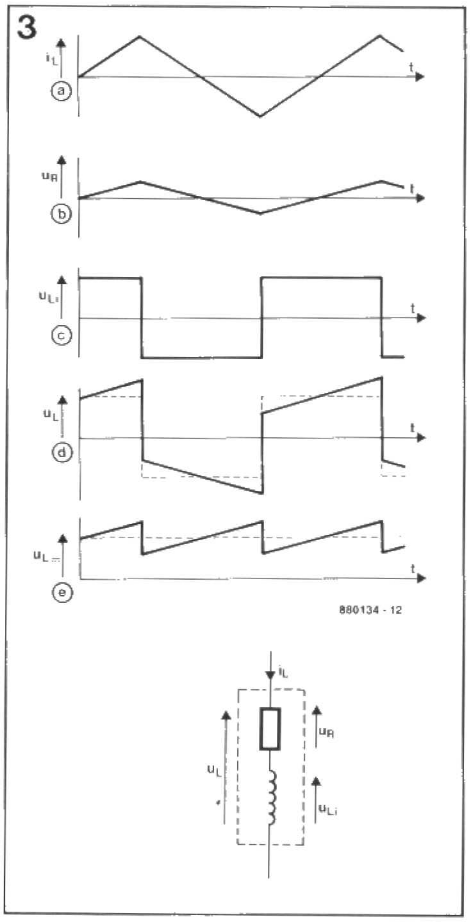


Fig. 3. In a practical inductor, its internal resistance causes a deviation from the rectangular shape of the induced e.m.f. The average value of this e.m.f. does not change, however.

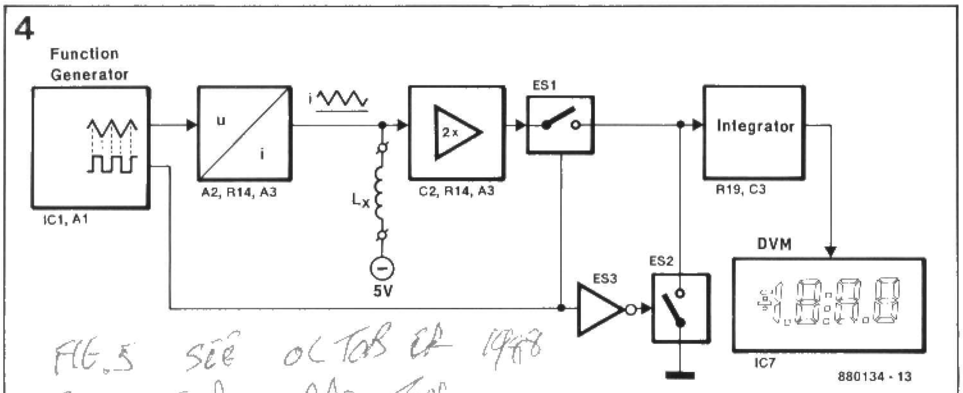


FIG. 5 SEE OCTOB EE 1988
P. 65 FOR CORRECTION

Fig. 4. The block diagram of the self-inductance meter.

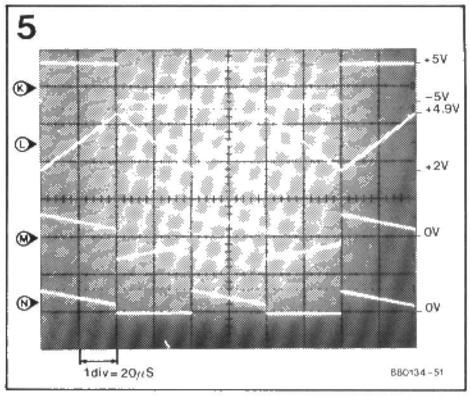


Fig. 5. The various waveforms in Fig. 4: L is the voltage applied to the voltage-to-current converter; a falling edge indicates an increasing current.

when an inductance of 2 mH is being measured on the lowest range, must be 200 mV.

In the following, it will be assumed that the maximum current, i_m, through the inductor is 20 mA (a reasonable value for inductors of 2 mH or smaller).

Starting at one edge of the triangular current,

$$di/dt = u_L/L = 200\times10^{-3}/2\times10^{-3} = 100.$$

Since the current increases linearly,

$$i_m/t_e = di/dt = 100$$

so that,

$$t_e = 20\times10^{-3}/100 = 2\times10^{-4} = 200\ \mu s,$$

where t_e is the duration of the edge. The frequency of the triangular current is therefore

$$f = 1/2t_e = 1/2\times2\times10^{-4} = 2500\ \text{Hz}.$$

Circuit description

The function generator consists of integrator A1 and Schmitt trigger IC1. The frequency of the generated signal is, as calculated above, 2500 Hz.

The Schmitt trigger provides a square-wave voltage that is used to control electronic switches ES1 to ES3.

Resistor R3 provides a DC offset to ensure that the triangular voltage does not drop below 0 V. This is necessary for good control of the voltage-to-current converter.

Circuit IC1 is a Type 3130 opamp, which is one of the few devices whose output voltage can really be driven positive and negative. That output serves as reference voltage for the following integrator.

The output of A1 is a triangular voltage, which varies between 4.9 V and 2 V. The voltage-to-current converter around A2 and T1 transforms this voltage into a current that is passed through the inductor on test, L_x.

The value of the current, and thus the measuring range, is determined by resistors R5 to R8. When the 2 H range is selected, the current is $20/10^4 = 0.02$ mA.

Resistors R9 to R11 in parallel with L_x provide some damping. This is necessary, because the inductor is also shunted by various parasitic capacitances (connecting wires, internal capacitance of the inductor, etc.) which results in an LC circuit. The high-impedance drive of this circuit (by a practically ideal current source) would certainly give rise to oscillations in the absence of some damping. The value of these resistors is chosen to ensure that they have a negligible effect on the measurement. Note that when the 2 H range is selected, R14 serves as damping element.

If an attempt is made to measure a small inductance with a high range selected, e.g., a coil of 1.5 mH in the 2 H range, it may be that the value of the damping resistor is too high, with the result that oscillations may occur. It is, therefore, advisable always to start in the lowest range and then switch to a higher range as required (shown by the absence of an overflow indication on the DVM). This method also ensures the highest possible resolution.

The overflow indication is provided by comparator A4, which connects the input of the voltmeter to +5 V via ES4 when too low a range has been selected.

Opamp A3 raises the magnitude of the measured alternating voltage by a factor 2. Note that C2 at its non-inverting input blocks any direct voltages. The offset of this opamp is compensated with the aid of P1.

The half-wave rectifier is formed by ES1 and ES2, while ES3 serves to invert the rectangular control pulses. During the positive part of the measured alternating voltage, ES1 is closed and ES2 is open; during the negative part, ES1 is open and ES2 is closed. The resulting steady voltage is smoothed with the aid of R19 and C3 and converted into a readable quantity by IC7.

The digital voltmeter consists of the well-known Type 7106 IC and a 3 ½-digit LCD. The 7106 contains all that is necessary for converting a steady voltage into a digital quantity and displaying this on the LCD. The decimal points of the display are provided by XORs N1 to N3. Which decimal point is visible depends on the position of switch S2c.

LEDs D8 and D9 indicate whether the display must be read in henrys or millihenrys.

The voltmeter is powered by two 9-volt PP3 batteries and two voltage regulators. Note that the 7805 and 7905 regulators provide better interference suppression than the smaller L types.

Specification

Measuring ranges	0.2–2 mH (resolution 1 μH)
	2–20 mH (resolution 10 μH)
	20–200 mH (resolution 0.1 mH)
	0.2–2 H (resolution 1 mH)

Internal resistance of coil for a measuring error smaller than 1% of full-scale deflection

Range		
	0.2–2 mH:	60R
	2–20 mH:	600R
	20–200 mH:	6 k
	0.2–2 H:	60 k

Measuring frequency	2500 Hz
Accuracy	Better than 2% of f.s.d.
Current drawn	About 20 mA

Construction

The meter, constructed on the PCB shown in Fig. 7, fits in a small, hand-held case.

All resistors and diodes are mounted upright, except R1, R3, and R24. Electrolytic capacitors should be PCB types. Sockets should be used for the ICs.

The display is best mounted on some stacked terminal boards so that it is located just under the window in the enclosure.

6

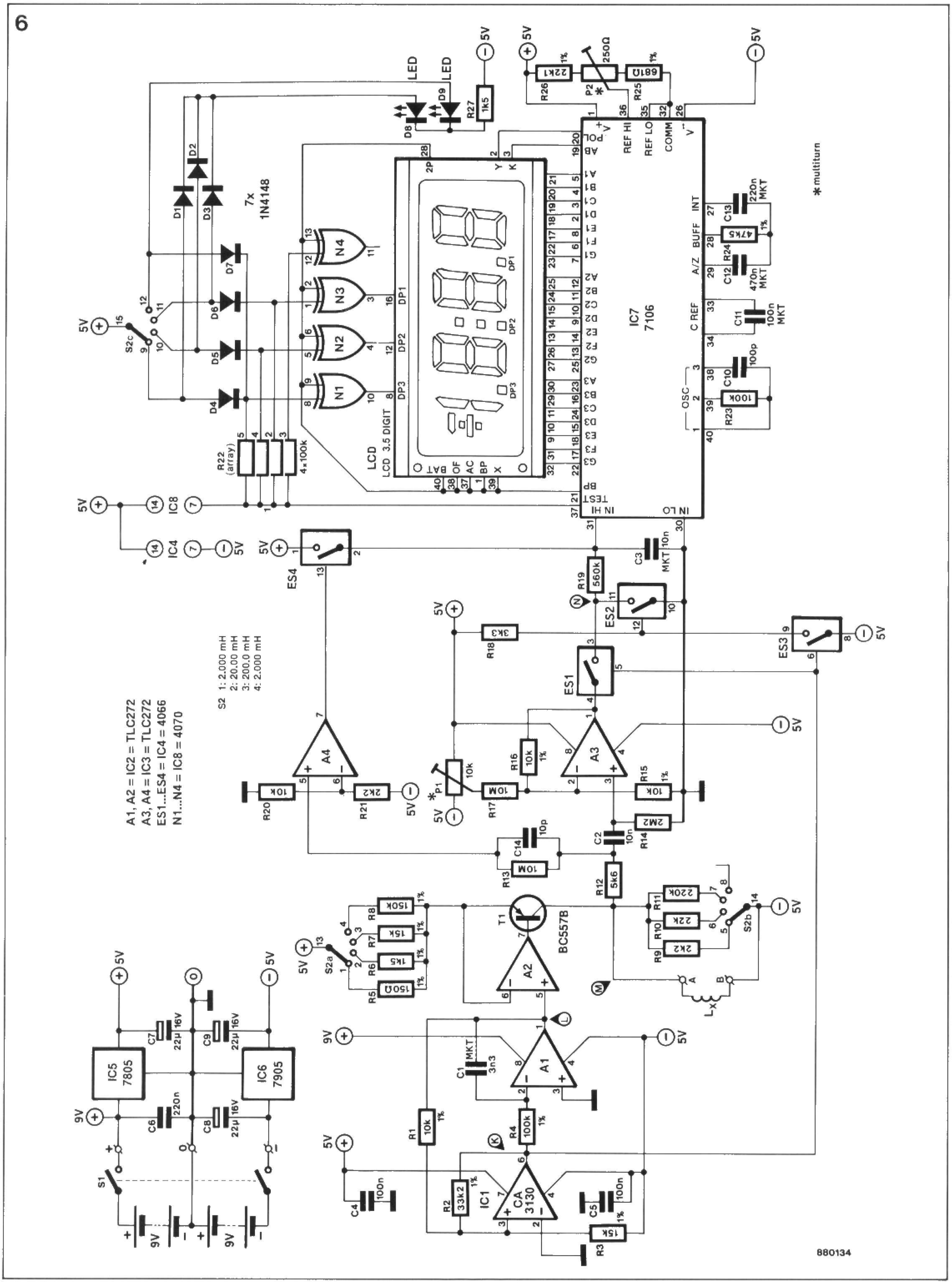


Fig. 6. The circuit diagram of the self-inductance meter.

Parts list

Resistors:
R1;R15;R16 = 10 k 1%
R2 = 33k2 1%
R3;R7 = 15 k 1%
R4 = 100 k 1%
R5 = 150R 1%
R6 = 1k5 1%
R8 = 150 k 1%
R9;R21 = 2k2
R10 = 22 k
R11 = 220 k
R12 = 5k6
R13;R17 = 10 M
R14 = 2M2
R18 = 3k3
R19 = 560 k
R20 = 10 k
R22 = array of 4 × 100 k or four discrete 100 k resistors
R23 = 100 k
R24 = 47k5 1%
R25 = 681R 1%
R26 = 22k1 1%
R27 = 1k5
P1 = 10 k multiturn preset (e.g. Bourns Type 3266)
P2 = 250R multiturn preset (e.g. Bourns Type 3266)

Capacitors:
C1 = 3n3*
C2;C3 = 10 n*
C4;C5 = 100 n
C6 = 220 n
C7;C8;C9 = 22 µ; 16 V (radial)
C10 = 100 p
C11 = 100 n*
C12 = 470 n*
C13 = 220 n*
C14 = 10 p

* metallized polyester or metallized polycarbonate

Semiconductors:
D1 to D7 = 1N4148
D8;D9 = LED 3 mm red
T1 = BC557B
IC1 = CA3130
IC2;IC3 = TLC272
IC4 = 4066
IC5 = 7805
IC6 = 7905
IC7 = 7106
IC8 = 4070

Miscellaneous:
LCD = 3 ½-digit liquid crystal display
S1 = double-pole on-off switch
S2 = rotary switch, 4-position, 3-pole
2 batteries, PP3 (9 V)
2 spring action terminals
enclosure 155 × 92 × 33 mm (e.g. OKW A9409111)
PCB Type 880134

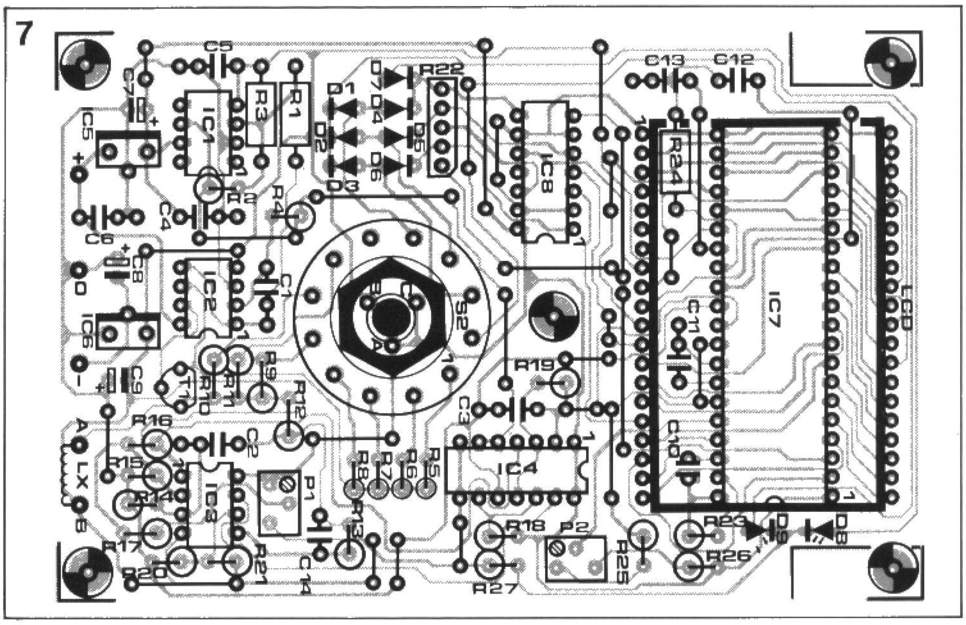


Fig. 7. The PCB for the self-inductance meter.

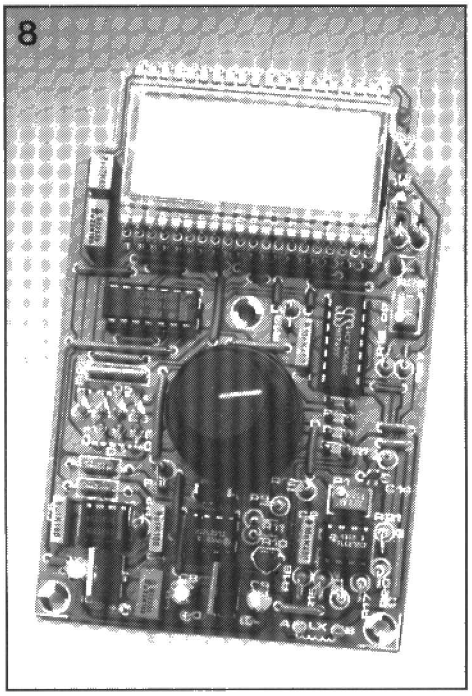


Fig. 8. Prototype of the self-inductance meter before it is fitted in the enclosure.

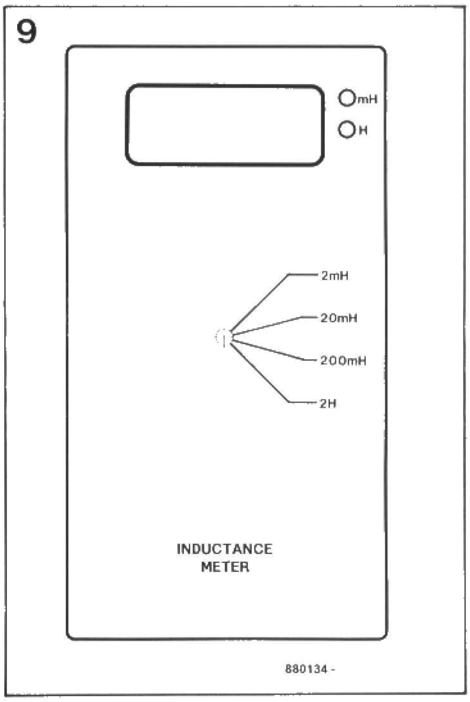


Fig. 9. Design of a possible front panel for the self-inductance meter.

R22 is an array of four 100 k resistors; this may be replaced by four discrete 100 k resistors that are mounted upright with their upper terminals interconnected.

The LEDs are mounted at such a height that they are seated just under the front panel once the PCB has been installed in the case.

The rotary switch is soldered direct to the PCB to make the best possible use of the available space and also to prevent noise and interference from connecting wires.

The centre pin of IC5 and IC6 should be bent forward so that the pins form a triangle (just as with a standard transistor). The ICs are mounted on the PCB with their case just clear of the board: this means that the wider part of the pins also goes into the relevant hole, which allows for this. Where a very flat enclosure is used (possible), it may be necessary to carefully cut off the metal tops of IC5 an IC6.

To secure the PCB, three holes must be drilled in the case: the non-populated board may be used as a template.

Switch S1 is best mounted at one of the sides of the case, while the two batteries may be located at the underside of the enclosure (after the small mouldings have been removed).

Note that the mouldings on the lid

should also be removed before the display is mounted.

The spring action terminals for connecting the inductor on test should be fitted at one of the sides of the enclosure as close as possible to the relevant pins on the PCB.

Calibration

An inductor of between 1 and 1.8 mH, whose value is accurately known, is required for the calibration. A cross-over filter coil with an accuracy of better than 3% may suffice, but some retailers can provide an air-cored inductor of 1.5 mH with an accuracy better than 1%.

It is also possible to determine the inductance of an air coil of about 1—1.5 mH accurately as follows. Connect it in parallel with a capacitor of 47 nF or 100 nF (accuracy 1% or 2%) and connect this circuit via a series resistor of about 3.3 k to a frequency generator. The resonance frequency of the circuit is then determined with the aid of an oscilloscope and a frequency meter. The self-inductance of the air coil is then calculated from

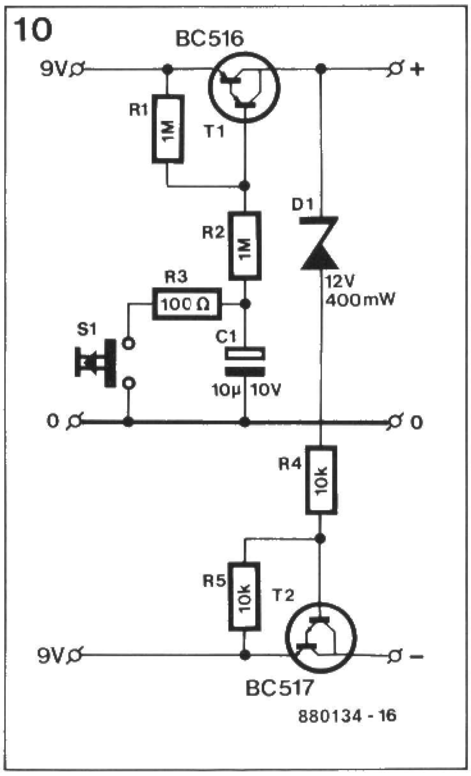


Fig. 10. This small circuit may be added to ensure automatic switch-off of the batteries.

$L = 1/(2\pi f)^2 C$ [H].

Short-circuit the measuring terminals and select the 20 mH range.

Adjust P1 till the display read 0.000.

Connect the reference coil to the measuring terminals and select the 2 mH range.

Adjust P2 till the display reads the exact value of the reference coil.

Since the accuracy and precision of the other ranges are determined by the tolerance of resistors R5 to R8, this completes the calibration.

Automatic switch-off

The meter draws about ±20 mA. A pair of batteries will have a fairly long life, as long as they are always switched off when the meter is not in use.

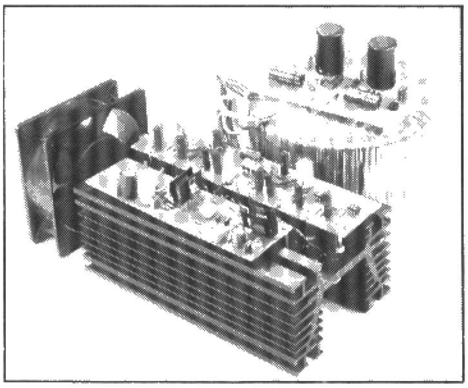
Forgetful users may find the circuit in Fig. 10 ideal: this automatically switches the batteries off after about half a minute. The meter is switched on again by pressing the reset button. This circuit may be connected behind S1 or simply replace it altogether. The meter is then always switched on by pressing the reset button.

AUDIO & HI-FI NEWS

Music-making control device

Synthesizers, samplers, and similar electronic sound sources can be controlled in a simple movement with a device developed by Electronic Music Studios. Called 'EMS Soundbeam', the device uses an ultrasonic echo sounder to detect the presence and range of any object that enters the beam, and converts the information into musical instrument digital interface (MIDI) data to control the electronic sound source.

Full information from Electronic Music Studios • Trendeal Vean Barn • Ladock • TRURO TR2 4NW • Telephone +44 726 883265.

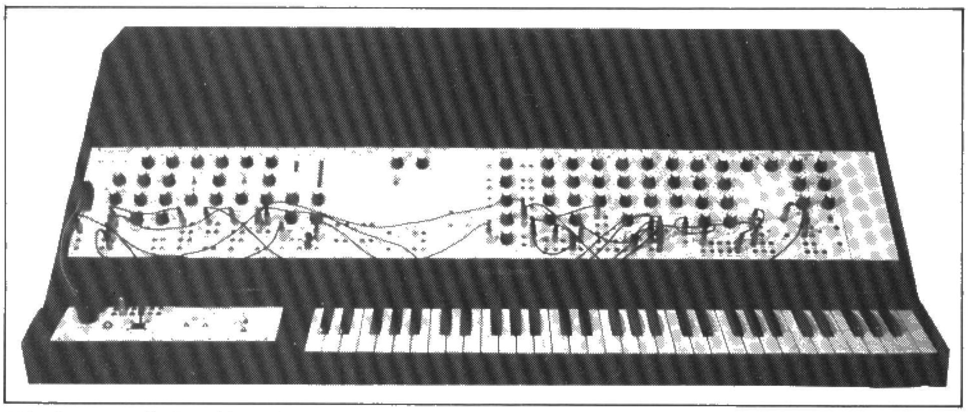


MOSFET amplifier kit from Maplin

A new 1 kW MOSFET Audio Amplifier Kit, the equivalent of products selling at £800 to £900, is available from Maplin at £193.00, excl. VAT.

The amplifier is intended for use in halls, auditoriums, or wherever the situation demands large-scale audio amplification. Loudspeakers can be driven by the amplifier at full power before protection circuits come into effect. A built-in monitor prevents the amplifier from delivering power continuously into a short-circuit. This may occur, for instance, when the loudspeaker cables are inadvertently shorted, rendering them liable to overheat very quickly - and often disastrously.

Write or phone for your nearest Maplin shop or to:
Maplin Electronics
PO Box 3
RAYLEIGH SS6 8LR
Telephone (0702) 552911



Digisound Synthesizers

All the kits of the Digisound 80 Modular Synthesizer are available from Tim Higham. The Digisound range will be expanded in the near future with a new polyphonic keyboard and a sound sampler.

For a free copy of the relevant catalogue write to Tim Higham • 16 Lauriston Road • LONDON SW19 4TQ.

Four times more music on a CD

A new recording technique capable of quadrupling the digital music data stored on a compact disc has been developed at Queen's University, Belfast. The technique will make it possible, for instance, to transmit high-quality music signals over the telephone network (since the signal bandwidth is reduced to 25% of that of current techniques). Another possible application is the transmission of high-quality music worldwide via satellite (because the transmission rate is reduced by a factor four compared with current systems).

MICROPHONE PREAMPLIFIER WITH ACTIVE FILTER

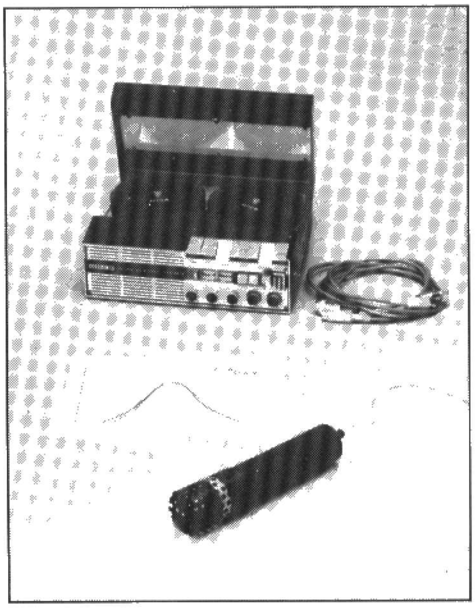
by S.G. Dimitriou

When a microphone is used a good distance away from an amplifier, its relatively small output signal is inevitably affected by noise and attenuation caused by the cable.
The simple, yet versatile, preamplifier/line driver described here can be used with a variety of microphones, has a user-defined frequency response, and prevents signal degradation because its ability to load long cables enables it to be installed near the signal source.

Many types of modern audio equipment have a built-in microphone, or allow an external microphone to be attached semi-permanently. This is the general case with portable tape or cassette recorders, video and movie cameras. In spite of the apparent benefits of having a built-in microphone, this will almost always pick up mechanical noise from the equipment it belongs to. Also, it is of little or no use when sounds from remote sources are to be recorded, as the level of ambient noise is bound to exceed that of the wanted sound.
Obviously, reasonable signal-to-noise ratios and, therefore, good-quality recordings, can only be achieved when the microphone — or microphones — is installed relatively close to the source of the sound, but this arrangement necessitates the use of a long coaxial cable between microphone and associated equipment. With cable capacitance typically of the order of 200 pF/m, up to 100 m of coaxial cable with $Z = 600\ \Omega$ may be used without running into considerable attenuation of the upper part of the audio spectrum. In this case, the cut-off frequency, f_c, becomes:

$$f_c = 1/(2\pi RC)\ \ [\mathrm{Hz}]$$
$$f_c = 1/(2\pi \times 600 \times 20 \times 10^{-9})\ \ [\mathrm{Hz}]$$
$$f_c = 13.263\ \mathrm{kHz}$$

In practice, however, the microphone impedance often rises with frequency, so that the cable must be kept shorter to prevent bandwidth reduction. In any case, it is not a very good idea to have the small microphone signal travel through any appreciable length of cable, as this will cause degradation of the signal-to-noise ratio.
A better method is to amplify the signal locally, i.e., as close as possible to the microphone, and drive the coaxial line by means of an amplifier with low output impedance. In this way, the wanted signal on the line is too strong to be affected by noise or capacitive loading. The signal amplitude can be reduced fairly easily at the receiver end with the aid of a two-resistor voltage divider (Fig. 1), in which



$$R_2 \approx 0.9 A R_1$$

where A is the amplification of the line driver, and $R_1 = 100\ \Omega$ (typical value).

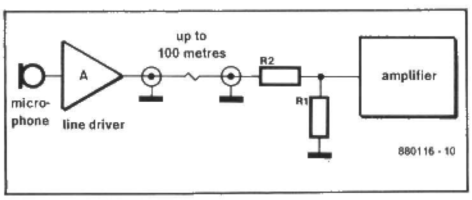


Fig. 1. A line driver with attenuator to overcome microphone signal degradation in a long coaxial cable.

Bandwidth and filtering

The line driver is readily modified to operate as an active filter that can help to improve the signal-to-noise ratio of the sound picked up by the microphone. This is particularly useful in applications involving the recording of speech signals. From acoustic engineering it is known that the frequency spectrum of speech has relatively large redundant parts. The dynamic and spectrum-related characteristics of speech have been widely studied, but a further discussion of this interesting field is, unfortunately, beyond the scope of this article. Here, it is sufficient to say that a simple Wien-type bandpass filter can aid in shaping the spectrum such that speech becomes more intelligible due to the elimination of redundant signals and a good deal of ambient noise. In this way, the signal-to-noise ratio of the sound picked up by the microphone is significantly improved.
The response of the standard, passive, Wien filter is fairly smooth (Fig. 2), making it suitable for use with music signals without unduly affecting the original sound.

Practical circuit

The preamplifier/active filter proprosed here is mainly intended for use with low-impedance dynamic or electret microphones. Electret microphones offer a wide frequency response, supply a relatively large output signal, and are of small size. They do have the disadvantage of requiring a biasing voltage, but this is no problem here as a supply is re-

quired anyway for the line driver.

With reference to the circuit diagram of Fig. 3, the line driver is built around low-noise operational amplifier IC_1, which is configured to work as an inverting active Wien filter. With the values shown for R_1, R_2, C_1 and C_2, the centre frequency of the filter will be 3.3 kHz nominally:

$f_0 = 159{,}155/(R_1C_1)$

with R_1 in kilo-ohms and C_1 in nanofarads. Related to the acoustic behaviour of the human ear, and with reference to the audible threshold curves set up by Fletcher and Munson [1], 3.3 kHz corresponds to the point of maximum sensitivity. The filter suppresses both low frequencies (whose reverberant nature tends to impair intelligibility of speech) and frequencies above 10 kHz, which can be considered as noise in the context of the spectral redundancy of speech.

The voltage amplification, A, of the line driver is about 10 at the passband centre frequency, and the value of the gain- and frequency- determining components is calculated from

$R_1 = 2A R_2$ and $C_2 = 2AC_1$

Components C_5 and R_5 ensure DC blocking at the output and phase stabilization respectively. The latter function is required to isolate the distributed capacitance of the coaxial cable from the feedback network of IC_1, thus preventing parasitic high-frequency oscillation. Evidently, the value of R_5 should be kept as low as possible, because otherwise the benefit of the low output impedance of IC_1 (as seen from the line) is lost. The resistor may be omitted if the LF356 is replaced with a (less expensive) 741, but this, unfortunately, increases the output noise level.

Potential divider R_3-R_4 biases the non-inverting input of IC_1 at half the supply voltage. LED D_1 is the power indicator. It is connected in series with the rest of the circuit to minimize the total current drain from the 9 V (PP3) battery. In this way, the preamplifier draws only 4.5 mA, which is still sufficient to light a LED with good efficiency. Owing to the drop across D_1, the preamplifier works from a supply voltage of 7 to 7.5 V.

Microphone and supply options

The basic circuit diagram of Fig. 3 shows a 3-terminal electret microphone. This will typically have an output impedance of 500 Ω or less, which is low with respect to the value of R_2, so that the microphone has very little effect on the centre frequency of the active filter. Where a 2-terminal electret microphone

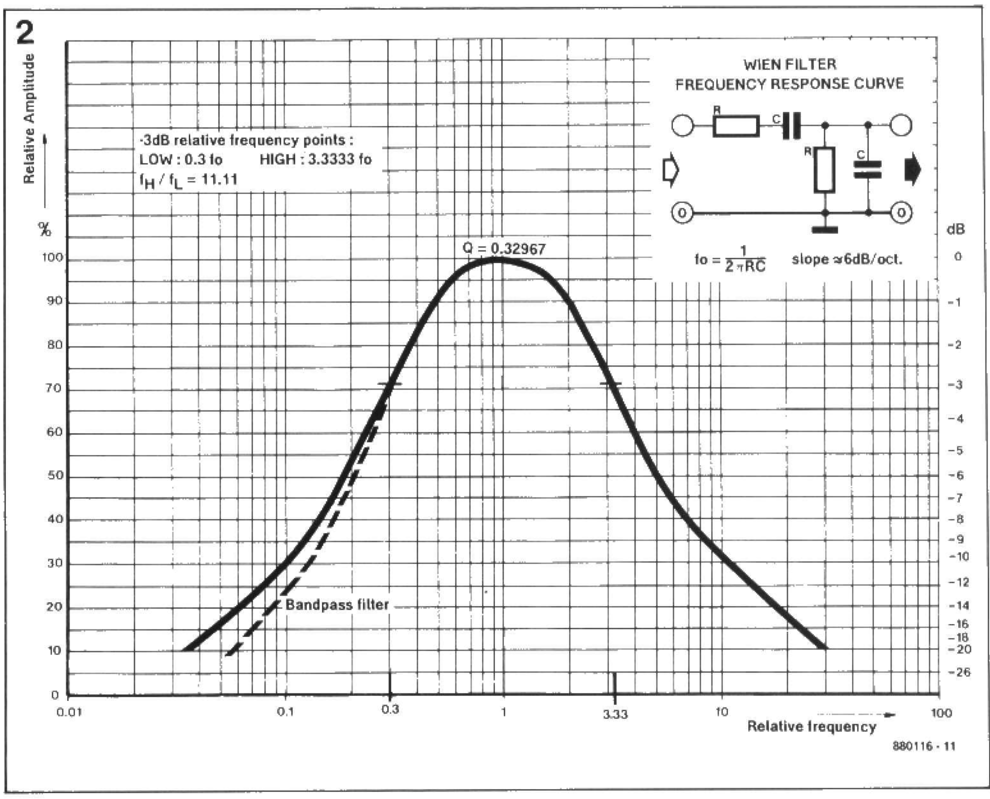


Fig. 2. Basic design and response of the Wien-type passive bandpass filter.

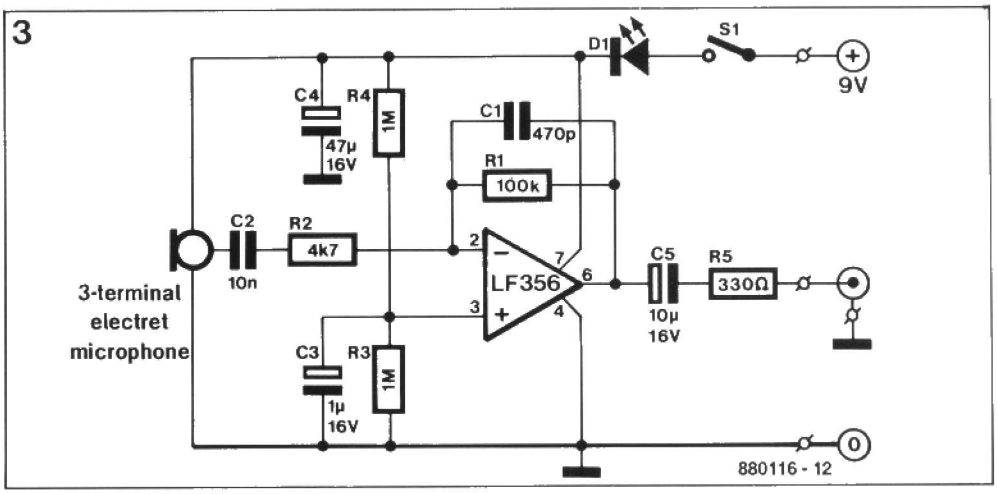


Fig. 3. Circuit diagram of the microphone preamplifier/line driver.

Table 1

Active filter response for $A = 5$

f_L (Hz)	f_0 (Hz)	f_H (Hz)	RC (µs)	BW (Hz)	R_1	C_1	R_2	C_2	Remarks/applications
217	723	2410	220	2193	220K	1n0	22K	10n	narrow bandwidth, mellow sound
300	1000	3333	150	3033	150K	1n0	15K	10n	narrow bandwidth, pronounced consonants
450	1500	5000	110	4550	330K	330p	33K	3n3	public-address response
660	2200	7333	72	6673	220K	330p	22K	3n3	narrow-band music reproduction
990	3300	11000	47	10010	47K	1n0	4K7	10n	for low-level hearing
1480	4800	16000	33	14650	100K	330p	10K	3n3	high harmonics content
208	--	6100	816 26	5900	68K	390p	12K	68n	speech intelligibility spectrum
20	--	20000	8160 7.95	19980	68K	120p	12K	680n	nominal Hi-Fi bandwidth

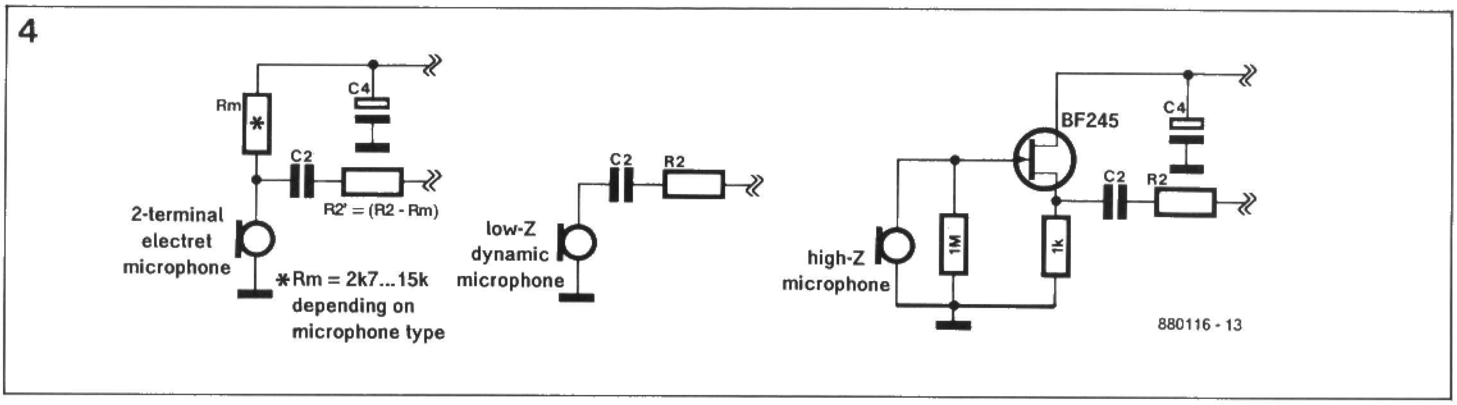


Fig. 4. Methods of connecting three types of microphone to the preamplifier input. Fig. 4a: 2-terminal electret microphone; Fig. 4b: low-impedance dynamic microphone; Fig. 4c: high-impedance dynamic or crystal microphone.

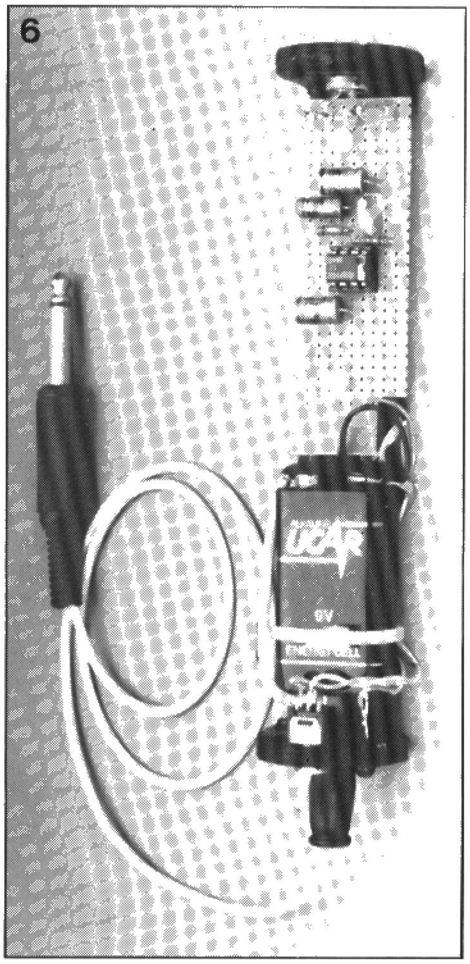


Fig. 6. The electret element and preamplifier mounted on a small piece of veroboard that can be inserted in a tube, together with the battery.

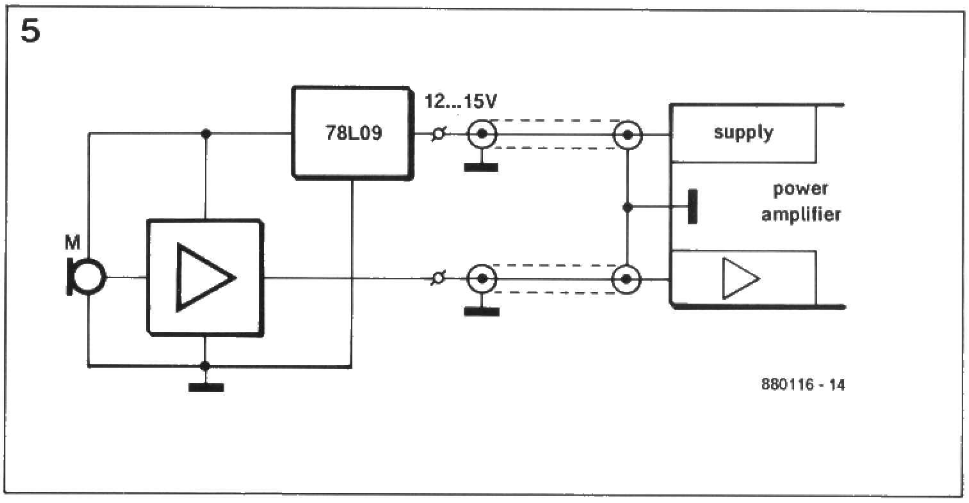


Fig. 5. The preamplifier can be powered via a separate wire in the cable to the power amplifier.

is used, the value of R_2 must be reduced to compensate the higher output impedance — see Fig. 4a. Figures 4b and 4c show the input circuits required for a low-impedance dynamic microphone and a high-impedance (or crystal-) microphone respectively.

As to the power supply for the preamplifier, this can be fed either by a battery as already discussed, or by an existing 12 to 15 V supply available in the power amplifier. In this case, only an additional 9 V regulator is required near to, or as part of, the microphone preamplifier. The +12 to 15 V input voltage for this regulator is conveniently carried via the centre core of one of the wires in the stereo shielded cable to the power amplifier.

Shaping the filter response

The centre frequency of the active filter set up around IC_1 can be selected for the application in question by redimensioning C_1, C_2, R_1 and R_2 on the basis of the previously shown formulas. Some commonly used frequencies and time constants are 723 Hz (220 μs), 1 kHz (150 μs), 1.5 kHz (110 μs), 2.2 kHz (72 μs), 3.3 kHz (47 μs) and 4.8 kHz (33 μs).

The filter can also be given a different frequency response. For example, it could be made wider to pass the spectrum from 200 Hz to 6100 Hz, which has been recommended for optimum intelligibility of speech [2]. For narrow-band music reproduction, a centre frequency of 1.5 kHz should be a good compromise between minimum required bandwidth and frequency response of loudspeakers typically used in public-address systems. Table 1 gives some useful design values and possible applications (voltage gain $A = 5$).

Construction

Construction of the preamplifier should be relatively easy on a small piece of Veroboard. This can be fitted in a cylindrical enclosure, together with the power switch, LED, battery and the microphone element — Fig. 6 shows a suggested arrangement. It is recommended to cover the battery and the board in small plastic bags to prevent any likelihood of a short-circuit. The excess material is wrapped around these elements, which are then carefully pushed into the tube. In this way, all parts are held securely in place without the need for mounting hardware.

References:

(1) *Audio handbook*, pp. 2-45. National Semiconductor Publication.
(2) *The Design of Speech Communication Systems*. Proceedings of the IRE, vol. 35, pp. 880-890, ed. 1947.

DIRECT BROADCAST BY SATELLITE CONFERENCE 1988

PANDORA'S BOX TO BE OPENED SOON?

Report of a two-day conference on direct broadcasting by satellite, organized by Consert, in association with 7 leading Institutions and Associations involved in electrical engineering, on 16 and 17 June 1988 at the IBA's Conference Centre, London. Road, London.

Most delegates attending the conference agreed that its timing was just right. After a rather silent period of about one year, satellite TV reception is a topical subject again. Recently, the new ECS-4 was taken into operation, and ESA's Ariane-4 rockets put Intelsat-5 (F13), Panamsat, Meteosat P2 and AMSAT Phase 3C into orbit. The failure late last year of TV-SAT1, the first West-German direct broadcasting satellite, was owing to faults in the satellite itself, not to the Ariane rocket, so that ESA's launch programme was not significantly delayed. But there were yet other factors that made the conference an important event. Astra, the first medium-power 16-channel commercial TV satellite, will be launched in November of this year, and, in Britain, the privately funded BSB (British Satellite Broadcasting) consortium announced that it had signed a contract with Hughes Aircraft Company for the on-orbit delivery of two Type HS376 TV satellites, the first of which is to beam down three high-power TV channels intended for private reception by means of a small dish. In accordance with WARC 1977 regulations, the BSB satellites will transmit from orbital position 31° west.

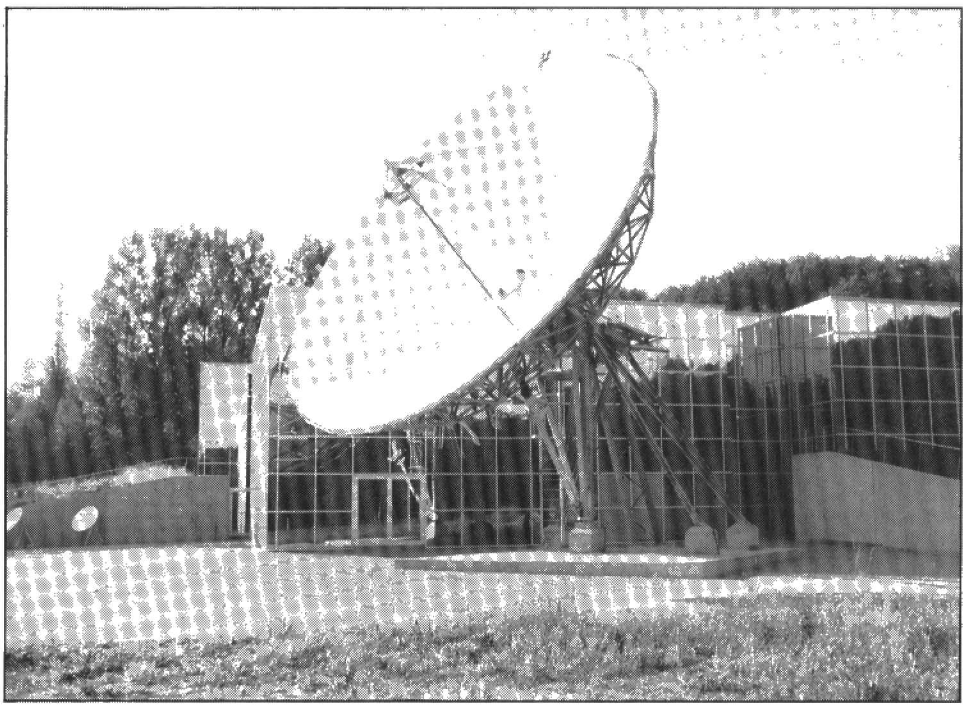
BSB opts for existing technology

The first of the two satellites ordered by BSB is scheduled for launching from Cape Canaveral, California, in August 1989 by a McDonnel Douglas Delta 4925 rocket. In their joint paper on the design and operation of the satellite, Michael Neumann and Tina Vargas of Hughes Aircraft Company explained that the HS376 is an existing design of proven reliability: it has six 55 W transponders, five of which can be used simultaneously in a number of configurations selected by the uplink station: the five TWTAs can be configured to provide three 110 W channels, two 110 W and two 55 W channels, or one 110 W and four 55 W channels. The transmit EIRP in the centre of the footprint will be 59 dBW minimum, allowing excellent reception throughout Great Britain with a 30 to 50 cm dish (G/T=16 dB; CCIR picture grade 3 or 4).

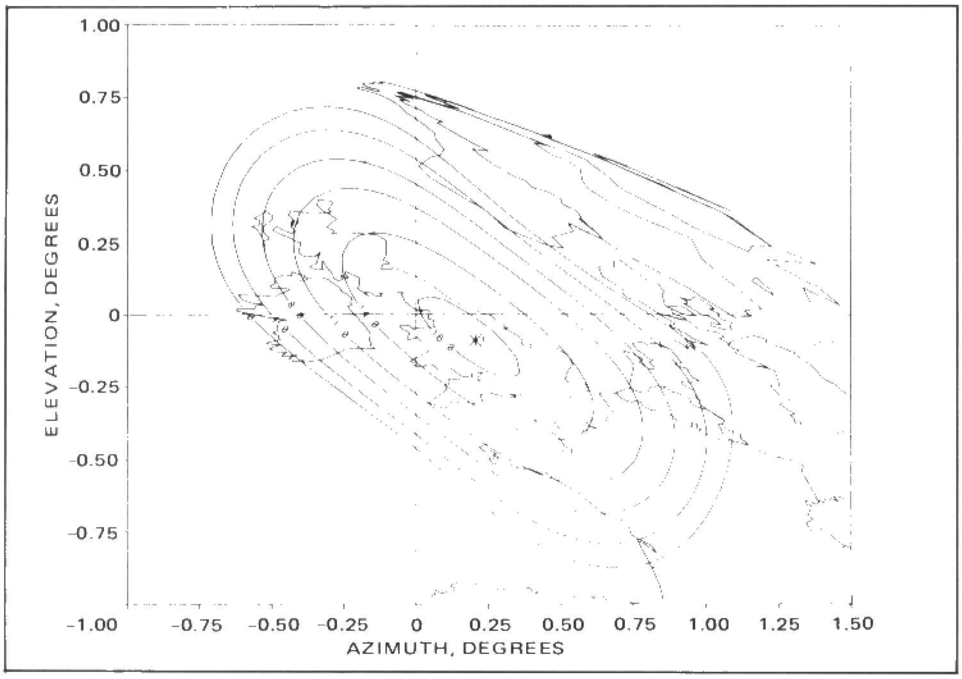
Brian Salkeld, in his paper on the history and structure of the BSB consurtium, the contracts with IBA and Hughes, and other general and commercial matters, informed the Conference that work had already been started on the construction of the BSB uplink station, located on a site at Chilworth, near Southampton.

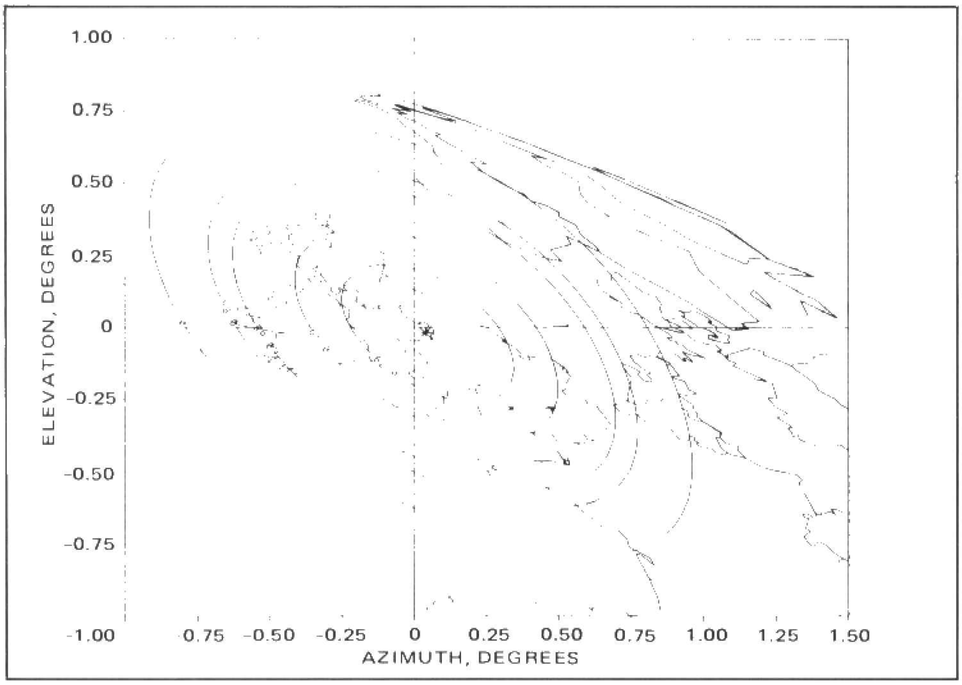
Europe's hot bird

Robin Crossley of SES (Societé Européenne des Satellites), the Luxembourg-based consortium that owns the Astra satellite, discoursed briefly on the state of affairs as regards the launching of this medium-power 16-channel TV satellite built by RCA and to be launched by ESA. The overall situation looks very favourable, as all transponders have been leased (10 via British Telecom), and ESA has not had launch failures recently, enabling them to schedule the launch of Astra for early November of this year, more than 16 months after the original launch date. Still, considering the delays that have occurred in the past, it may be more realistic to expect the launch to take place in January or February of next year (but the pessimists may be wrong this time). Astra will transmit 16 TV channels from orbital position 19.2° East. It will carry a miscellany of programmes in PAL, D-MAC, D2-MAC and, possibly, C-MAC, with scrambling allowed by SES. Astra is not a DB satellite, i.e., it will transmit in the CSS band (11.2 GHz to 11.45 GHz). The satellite's EIRP of more than 50 dBW over most of Europe should enable excellent reception in Great Britain with dishes of 60 cm or more.



The uplink dish at the Astra TT&C centre in Betzdorf, Luxembourg, has a diameter of 11 m.





Provisional receive G/T (upper drawing) and transmit EIRP (lower drawing) of the BSB satellite built by Hughes Aircraft.

Hands-on experience

After a number of papers on the basic concepts of satellite TV transmission and reception, and the so-called space segment, it was Mr. Tony Finch of Satellite TV Systems, Brighton, who put delegates' feet firmly on the ground again by presenting a paper on practical problems encountered during the setting up of receiving equipment. This lecture was among the best received, because Mr. Finch gave a number of useful tips gathered from his experience as a technical consultant and dish installer. Among the subjects covered by Mr. Finch were protection of the outdoor unit against the weather, simple tools and equipment used for aligning the dish, choice and length of the IF cable, and servicing experience.

His last subject, planning permission, was particularly interesting because this has caused great confusion in the past. To encourage the use of DBS receiving equipment, the government has removed the need to obtain planning permission for dish aerials which are 90 cm or less in diameter. The Town and County Planning General Developnent Order of 1985 permits the intallation of *one* dish provided it is mounted no higher than the highest part of the roof.

A further paper that focused mainly on practical problems was that delivered by Mr. M. Talvo of Salora OY. The main subjects were the design and use of a set-top box for MAC decoding, and interfacing of an indoor unit plus MAC decoder to existing audio and video equipment. Mr. Talvo first explained the basic operation of the MAC decoder still to be marketed by ITT Intermetall, and then went on to discuss the practical use of a MAC decoder module in the indoor unit marketed by Salora. Mr. Talvo's message was clear: connecting a satellite receiver system to existing audio and video equipment may be far more difficult than some retailers would have customers believe, especially when MAC decoders and associated decryption or pay-as-you-view units become available.

Battle no. 1: Intermetall vs Philips Components...

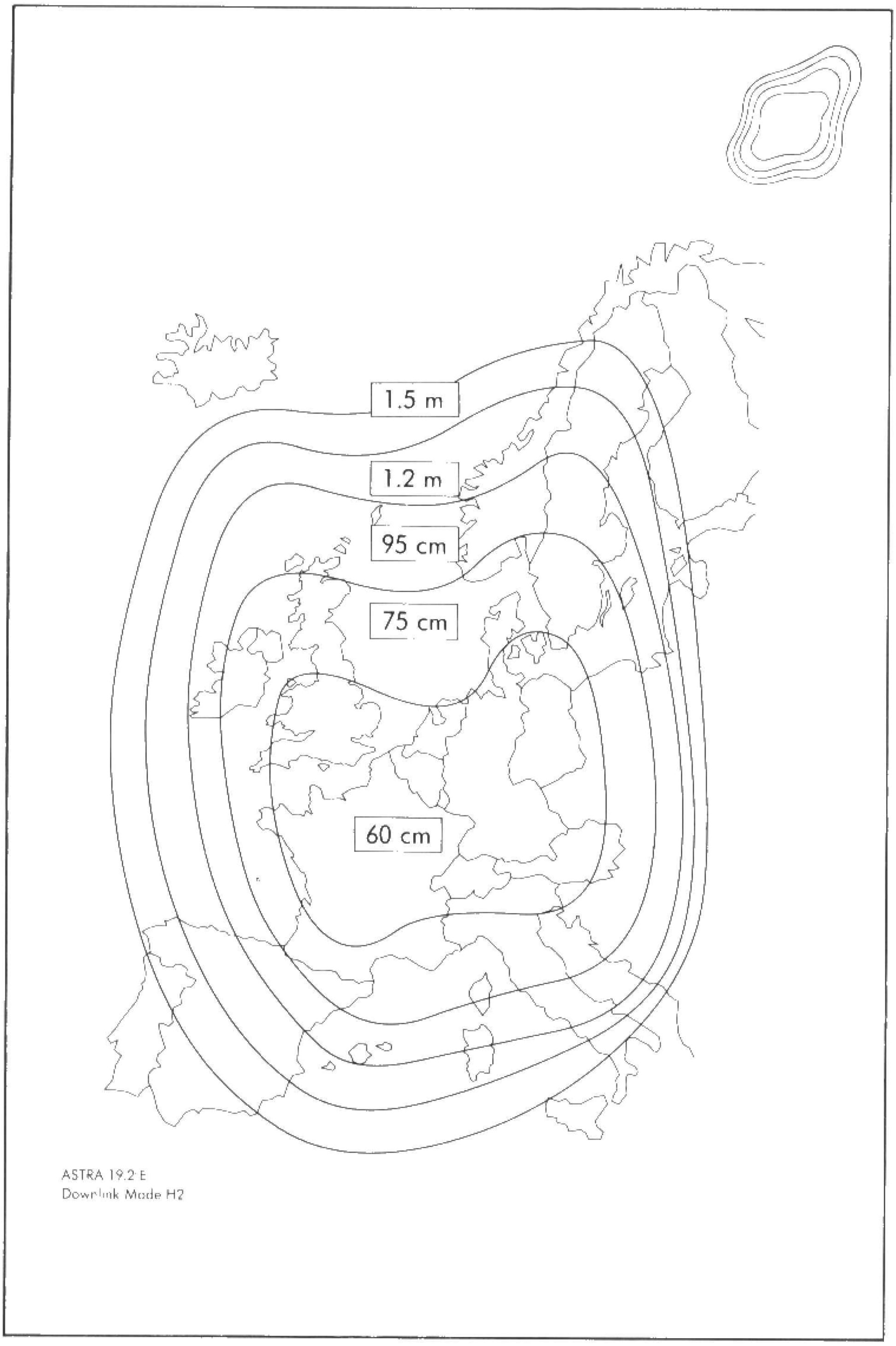
BSB recently commissioned Intermetall to manufacture D-MAC decoder chips. To many delegates, this came as a surprise, mainly because:

- at the time of writing this article (early July 1988), ITT has not yet commenced mass production of their D2-MAC chip set, from which the D-MAC set is to be derived. Considering that Intermetall have had, or are still having, great difficulty producing 'full-spec' D2-MAC chip sets for delivery to the German and French TVRO industry, it may take a further six months or so before the D-MAC version becomes available.
- Philips Components (formerly Mullard) claim to be ahead of Intermetall in the development and testing of a multi-standard MAC decoder. Contrary to the Intermetall design, this module has extensive descrambling facilities, and can handle C-MAC, D-MAC and D2-MAC signals [3]. In a lucid and technically interesting paper, Mr. M. Brett of Philips Components gave a detailed description of the operation of the new multi-standard chip set.

From the above it would appear that BSB's choice in favour of the ITT chip set was governed mainly by cost. Compared to the system proposed by Philips' [3], the ITT chip set is less complex and, therefore, likely to be less expensive. As is probably known from the newspapers, BSB has invited 15 companies to tender for the supply of a complete receiving system, with an aim to keep the cost below £200. Obviously, because all three signals on the BSB satellite will be in D-MAC (with possible encryption), the cost of the complete vision, sound and descrambling unit must not add too much to that of the dish and the LNC.

Battle no. 2: PAL vs MAC

BSB and IBA have chosen D-MAC, not D2-MAC, as the transmission standard on the future 3-channel British DB satellite. The reasons for this decision are perfectly clear. D2-MAC is a 'low-



Astra footprint. Contours indicate typical dish size for CCIR picture grade 4 ('good'). Boresight EIRP is 52 dBW.

	TDF-1	Astra	BSB-1
provisional launch in	9-88	11-88	9-89
country	F	UK/LX/D/F	UK
satellite built by	Euro Spatiale	RCA	Hughes Aircraft
launch vehicle	Ariane 4	Ariane 4	McDonnel Douglas D-4925
funding	government	SES/private	BSB/private
programmes	national	commercial	commercial
no. of channels	4	16	3
EIRP (bore sight)	63 dBW	50-52 dBW	59 dBW
polarisation	circular CCW	linear H/V	circular CW
transmit power	250 W	50 W	110 W
frequency band	DBS 12 GHz	CSS 11.5 GHz	DBS 12 GHz
orbital position	19° W	19.2° E	31° W
dish size for C/N>15 dB	40 cm	75 cm	40 cm
transmission standard	D2-MAC	D2-MAC, D-MAC, C-MAC, PAL	D-MAC
encryption	possible; EBU-MAC	possible: various systems	Eurocypher

bandwidth' version of D-MAC, developed to enable relaying DB satellite signals on to cable systems [2]. In France, Belgium, West Gernmany and Holland, the percentage of households receiving TV programmes via a cable network is far higher than in the UK (about 40% on average against less than 3% in the UK). D-MAC signals of about 12 MHz bandwidth are simply too wide to fit in channel allocations on existing cable networks, and France and West Germany, are, therefore, forced to use D2-MAC (8.5 MHz) on their DB satellites. Obviously, D-MAC is techically superior to D2-MAC, but if it were to be used on the German and French DB satellites, the ludicrous situation would arise of millions of cable viewers being unable to see the national programmes intended for direct and private reception.

In the UK, this problem does not arise because of the relatively low number of cable viewers, so that the full potential of D-MAC (8 sound channels, data rate = 20.25 MHz) can be exploited.

But what about the cable viewers in the UK? Will they be able to see BSB and Astra programmes? Here, the situation is quite complex. Mr. Viv Lewis of Wolsey Electronics Ltd. gave an interesting paper on the conversion and updating of SMATV and MATV cable systems in the UK to enable the relaying of high-quality TV and audio channels that will shortly be received from Astra. The problems SMATV installers are faced with are complex, to say the least. By means of a hypothetical situation, Mr. Lewis demonstrated the difficulties and pitfalls that may be encountered during the planning of the channel assignment in a SMATV system. A large number of factors have to be taken into account before the system installer can arrive at the final version of the channel allocation chart: the system will have to carry the four national TV channels, to which two or three additional 'out of range' UHF channels may be added, in-house video/sound channels (pay-TV channels in hotels), and a number of VHF FM radio channels. Obviously, planning becomes even more difficult when such a system is to be extended to carry, for instance, all eight English-language TV channels to be transmitted by Astra. Fortunately, recently developed and tightly specified VSB (vestigidal sideband) modulators use up only half the bandwidth required by the traditional DSB (double-sideband) modulator. When used throughout the SMATV system, VSB modulators can help to avoid cross-channel interference, overloading of receivers, or excessive attenuation of high-frequency channels.

How do SMATV operators put a satellite TV signal on to a cable system? Basically, the received vision spectrum is frequency-demodulated at 480 MHz,

filtered, and then converted to AM with the aid of UHF band modulators that suppress the redundant lower sideband. Whether or not remodulation to VSB AM on UHF will affect the original quality of the transmission is a matter to be addressed yet by SMATV installers.

Battle no. 3: Videocypher vs Eurocypher...

In principle, all versions of MAC allow complex digital scrambling of vision and sound. In this context, the terms conditional access, encryption, scrambling, pay-as-you-view and tiering all have different meanings. This was made clear in the paper delivered by Mr. Paul Hyde of Ewbank Preece Ltd., a company specialized in the design of encryption systems. Mr. Hyde showed the differences between a number of levels of scrambling, with reference to systems and standards already available. General Instrument will supply the conditional access system to be used on the BSB satellites. This system will be called Eurocypher, and is basically a MAC-compatible version of the North American Videocypher system developed by GI. After Mr. Hyde's lecture, one Conference delegate broke the news that the original Videocypher scrambling system had recently been broken by a group of software hackers in the USA.

Battle no. 4: Astra vs BSB-1

The previously discussed areas of conflict were the source of lively discussions between delegates as well as delegates and speakers. In a few months' time, when complete Astra receiving systems will be available from radio and TV retailers, many technically non-interested TV viewers in the UK will start wondering if this set can also be used for the future UK DBS services. After all, as far as unobtrusive installation is concerned, it will not make much difference whether a 60 cm or 30 to 50 cm dish is being used. The many radio and TV retailers among the conference delegates will probably have a hard time explaining to potential customers that:

1. for BSB, a 12 GHz LNB with circular feed is needed instead of a 11.5 GHz LNB with a linear feed for Astra (two-band LNBs with linear and circular inputs are simply not yet available);
2. the orbital spacing between BSB and Astra is about 50°, requiring either a polar-mount plus control unit, or two dishes (this may be less expensive, but what about the planning permission?);
3. it is not certain yet that all transponder users on Astra will use the same encryption standard;
4. the customer's TV set should have a SCART input to avoid loss of quality in a remodulator;
5. PAL is completely incompatible with any of the MAC standards, as is D-MAC with D2-MAC, and vice versa. The ITT chip set may be suitable for some channels on Astra, while the Philips set can handle all standards, but will probably be marketed as a set-top box.

In Europe, there exists a long-standing tradition to use a bewildering number of different standards and systems. The many interesting papers delivered during the Conference on Direct Broadcasting by Satellite, however, provided an excellent overview of the current situation, which is probably best described as Pandora's box, about to be opened.

Background to terms and abbreviations:

(1) Satellite TV reception. *Elektor Electronics* September 1986.
(2) The MAC system. *Elektor Electronics* July/August 1987.
(3) Multi-standard MAC decoder announced. Radio & TV News, *Elektor Electronics* March 1988.

RADIO & TV NEWS

More UK backing for high definition TV project

Britain is to increase its backing for plans to develop a high definition television system by £1.7 million to £4.8 million.
UK Minister of Trade and Industry Mr Kenneth Clarke says the extra money will be used to support the participation in the project by the Quantel company and the British-based Philips Research Laboratories.
Quantel will develop a range of high definition editing and image manipulation equipment and Philips Research Laboratories will be making a major contribution to research into picture analysis and coding techniques associated with the transmission and display of high definition signals.
High Definition Television uses approximately twice the number of lines compared with standard definition to produce and display TV pictures of a quality comparable to that of 35 mm film.
The aim of the HDTV project, which involves some 30 European industrial companies, broadcasters and research institutes, is to define a standard for HDTV which is compatible with the MAC (Multiplexed Analogue Components) transmission system being introduced for Direct Broadcasting by Satellite (DBS) services in Europe. The project will develop and demonstrate, by 1990, a complete prototype production and transmission system for MAC-compatible HDTV.
A major demonstration of the new system will take place at the International Broadcasting Convention in Brighton this month. Further demonstrations will take place in 1989, with the objective of having the system adopted as a world standard by the CCIR (the international radio standards body) in 1990.
The HDTV project is part of Europe's Eureka initiative launched in 1985 with the object of encouraging collaboration to increase European competitiveness in the exploitation of technologies. The initiative has evolved into a flexible framework to encourage industry-led collaborative projects aimed at producing high-technology goods and services to compete in world markets, using the European market as a springboard. There are likely to be 200 Eureka projects, 74 of them involving the UK.

Facsimile receiver for weather charts

A facsimile receiver for the meteorological information, including weather charts, which is broadcast on a worldwide basis, is available from Littlemore Scientific.
the 'W-Fax 869' is based on a decoder which processes information broadcast by meteorological offices around the world. A standard 13 in (330 mm) dot-matrix printer produces a wide variety of weather charts covering conditions for aviation and shipping, temperatures and gale warnings, and satellite photographs.
The user simply tunes to the required station, sets the equipment to 'auto' and leaves it to print out the charts as they are received, appropriately marked with time and date.
The system will also decode Navtex messages, including weather forecasts, gale warnings, marine navigational warnings, ice reports and search-and-rescue operations. Land-based operators can exclude marine information if they wish.
The system can print radioteletype messages transmitted in Baudot or ASCII at rates up to 200 baud.
The W-Fax 869 consists of a radio receiver with 455 kHz intermediate frequency, antenna, decoder and printer. It normally works from a mains a.c. supply, but can also be supplied for 12 V or 24 V d.c. operation.
(Littlemore Scientific Engineering Co, Railway Lane, Littlemore, OXFORD OX4 4PZ. Telephone: +44 865 747437; Telex: 837686; Fax: +44 865 747780)

EVENTS

IEE Meetings

4 – 9 Sept **Switching and signalling in telecommunication networks** - Ninth vacation school at the University of Aston.

4 – 10 Sept **Measurement technology (DC to VHF)** - Vacation school at the University of Aston.

11 – 15 Sept **Optical communication (ECOC)** - Fourteenth European conference and exhibition in Brighton.

11 – 16 Sept **Telecommunication network design and performance** - Vacation school at the University of Strathclyde.

23 – 27 Sept **International Broadcasting Convention (IBC)** - Conference and exhibition in Brighton.

Further details on the above events may be obtained from the Secretary, IEE, Savoy Place, LONDON WC2R 0BL, telephone 01-240 1871.

An **International IARU Amateur Television** contest will take place from 1800 GMT on Saturday 10 September to 1200 GMT on Sunday 11 September.
An **International Slow Scan TV** contest will be held on Sunday 13 November from 0001 to 2359 GMT.
Details of these events from Mike Wooding, 5 Ware Orchard, BARBY CV23 8UF, telephone (0788) 890365.

Correction

Test and Transducer International, the instrumentation exhibition and conference, will NOT take place as announced in our July/August issue. The organizers have now decided to hold the exhibition at the **Wembley Exhibition Hall, London**, on 26 and 27 October. The conference has, unfortunately, been cancelled.

The **International Exhibition and Flying Display** at Farnborough will take place from 4 to 11 September. Details from Society of British Aerospace Companies Ltd, 29 King Street, St. James's, LONDON SW1Y 6RD, Telephone +44 1839 3231, Telex 262274.

The **Electronic Displays** Exhibition will be held at the Wembley Exhibition and Conference Centre, London, on 4—6 October. Details from Blenheim Online, Blenheim House, Ash Hill Drive, PINNER HA5 2AE, Telephone +44 1868 4466, Telex 923498, FAX +44 1868 9933.

CONPAR 88 will be held on 10 – 16 Sept in Manchester. Further details from the British Computer Society, 13 Mansfield Street, LONDON W1M 0BP, telephone 01-637 0471.

The sixth international conference on **Electromagnetic compatibility** will be held at the University of York on 11 – 15 Sept. Further details from the Institution of Electronic and Radio Engineers, Savoy Hill House, Savoy Hill, LONDON WC2R 0JD, telephone 01-240 1871, Ext. 246.

An **Artificial intelligence in real-time control** workshop will be held at the University College of Swansea on 21 – 24 Sept. Further details from the Institute of Measurement and Control, 87 Gower Street, LONDON WC1E 6AA, telephone 01-387 4949.

The **Electronics India Exhibition** will be held in New Delhi on 6 – 11 Sept. Further information from GAMBICA, 8 Leicester Street, LONDON WC2H 7BN, telephone 01-437 0678.

The **World Administrative Radio Conference** on the use of the geostationary-satellite orbit and on the planning of space services utilizing it will be held in Geneva from 29 August to 5 October.

A **Mobile Radio Communications Exhibition** will be held at Sandown Park, Esher, on 13 – 15 Sept. Further details from Framework, telephone 01-778 5656.

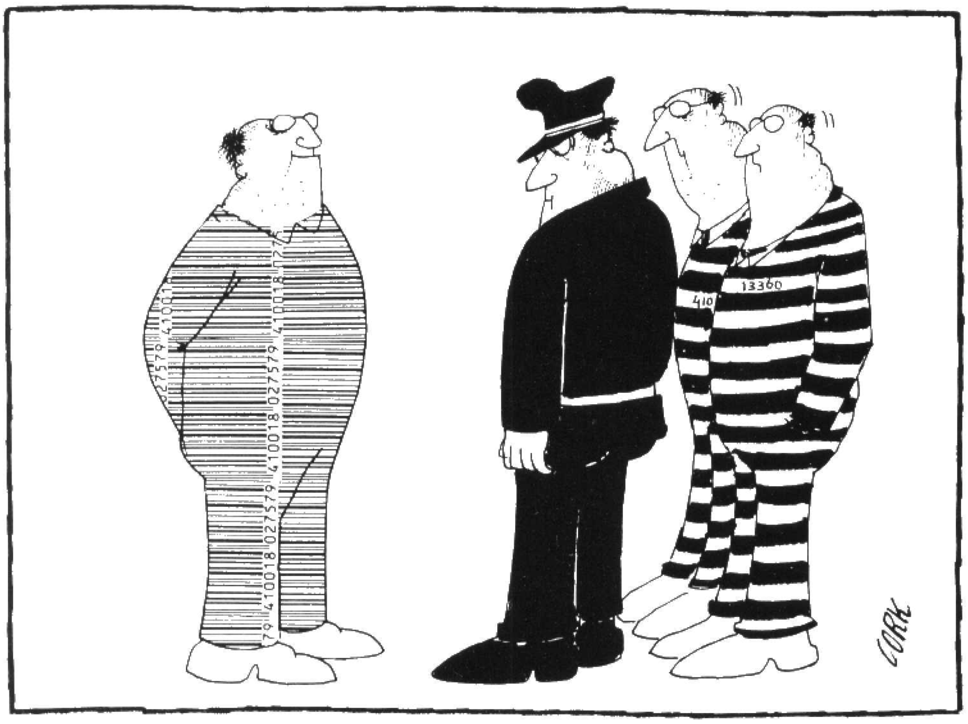
The **Electronics Industry Exhibition** will be held in Hong Kong on 15 – 18 Sept. Further details from ADG Exhibitions, telephone (0243) 29406.

The **Canadian High Technology Week** will be held in Toronto on 27 – 29 Sept. Further details from Overseas Trade Agencies, telephone 01-486 1951.

The **Semiconductor International Exhibition** will be held at the NEC, Birmingham, on 27-29 Sept. Further information from Cahners Exhibitions, Chatsworth House, 59 London Road, TWICKENHAM TW1 3SZ, telephone 01-891 5051.

The **Light and Sound Show** (sound, lighting, video, lasers, equipment and accessories for leisure industries) will be held at Olympia 2, London, on 11 – 14 Sept. Further information from the Professional Lighting and Sound Association, 1 West Ruislip Station, RUISLIP WA4 7DW, telephone (08956) 34515.

ERA Technology is to organize a **Conference on coil winding** which will run in tandem with the **Coil Winding International Exhibition** being staged by Evan Steadman (Services) Ltd on 6 – 8 Sept at the Wembley Conference Centre, London. Further information from ERA Technology Ltd, Cleeve Road, LEATHERHEAD KT22 7SA, telephone (0372) 374151, or Evan Steadman (Services) Ltd, The Hub, Emson Close, SAFFRON WALDEN CB10 1HL, telephone (0779) 26699.

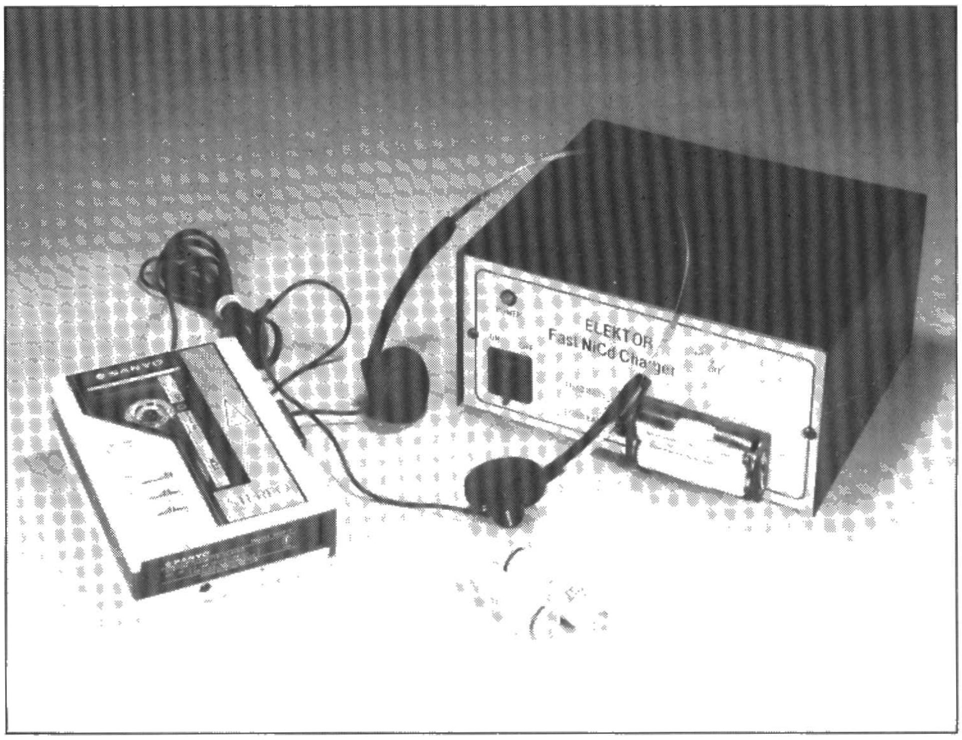


FAST NICD CHARGER

Most popular personal radios suffer from high current consumption, so that it is sensible to power them from rechargeable batteries. Unfortunately, with most battery chargers on the market it takes up to 15 hours to recharge batteries. The charger proposed here does it in under an hour.

Most of the smaller NiCd batteries on the market today have sintered electrodes that can withstand fairly high currents. This makes it possible for such batteries with capacities up to about 500 mAh to be recharged to 80% of their capacity within an hour.

The problem with fast charging of NiCd batteries is switching off the charge current at the right time. With these batteries, unlike, for instance, lead-acid batteries, it is not possible to determine this from the charging voltage.



The circuit

The circuit consists of four distinct sections as shown in Fig. 3. In Fig. 3a are the supply section with rectifier, B_1, and 5-V voltage regulator, IC_1, and a Type 4060 timer, IC_4. The sections in Fig. 3b and Fig. 3c are identical to enable the charging of two LR6-size (U7) batteries. It should be noted that batteries cannot be connected in series in a voltage-controlled charger, because the batteries are never fully charged at the same time.

Each of the sections in Fig. 3b and Fig. 3c consists of a charging voltage monitor and switch, IC_2 (IC_3), and a Type BD680 darlington, T_1 (T_2), which functions as the source of the charging current.

The supply section is provided with an 'on' indicator, D_{11}. The input comes from a mains transformer with an 8-V, 1.5 A secondary. The rectified voltage is smoothed by C_3. The regulated 5-V output of IC_1 is used as reference voltage and to power IC_4.

The clock in the 4060 operates at a frequency of 2.5 Hz, determined by R_{10} and C_6. After 2^{13} (=8192) clock pulses (= about 54 mins) from reset key S_1 being pressed, output Q_{14} (pin 3) becomes logic high.

The reference voltage for IC_2 and IC_3 is derived from the regulated 5-V output of IC_1 by potential divider R_1—P_1—R_2. The reference voltage is the value of the battery voltage at which the charging process must be terminated: it is invariably 1.5 V.

The reference voltage is applied to the inverting input of IC_2 (IC_3) via R_3 (R_4). The battery voltage is applied to the non-inverting input of the opamps. The ICs also function as bistables, which, together with IC_4, are provided by S_1 with a set pulse at the onset of the charging process.

When S_1 is pressed, the inverting input of IC_2 (IC_3) is briefly connected to +8 V via D_1. That is sufficient to switch the output of the opamps to 0 V. If the battery voltage is lower than the reference voltage, the comparator remains in this state and current source T_1 is switched on. A current of about 0.5 A then flows through the battery (batteries) and D_4 (D_9) lights. This LED does not only serve as charging indicator, but, in conjunction with D_3 (D_8), also serves as voltage reference for T_1 (T_2). The magnitude of the charging current is determined by the value of R_8 (R_{19}).

When the potential across the battery becomes greater than the reference voltage, the relevant opamp (IC_2 or IC_3) toggles. Its output then becomes logic high and the charging process stops, because no base current can flow in the current source, which therefore switches off. The feedback via R_4 (R_{15}) and D_2 (D_7) maintains the opamp in this state. It can only be reactuated by S_1.

If, because of a disparity between the battery and reference voltages the current source is not switched off, the timer comes into action. After about 54 minutes (see above), output Q_{14} (pin 3) becomes logic high, which causes the opamps to be reset and thus terminate the charging cycle.

Extra charge

After about 54 minutes, the batteries are charged to something like 80% of their capacity, which is sufficient for their use in the personal radio. Considering that many of such radios draw a current of around 100 mA, the batteries will give

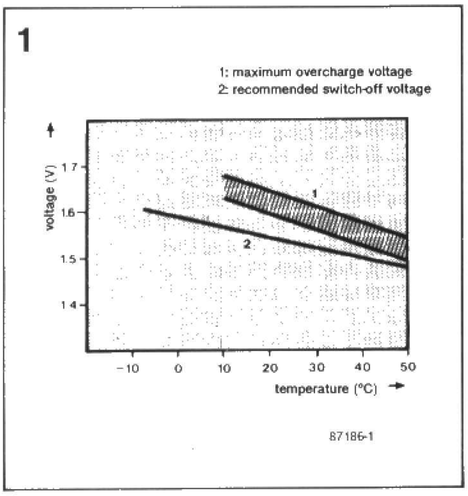


Fig. 1. Recommended switch-off voltage and over-charge voltage pertaining to sintered NiCd cells as a function of ambient temperature during charging. It is not advisable to use fast charging at ambient temperatures below 10° C.

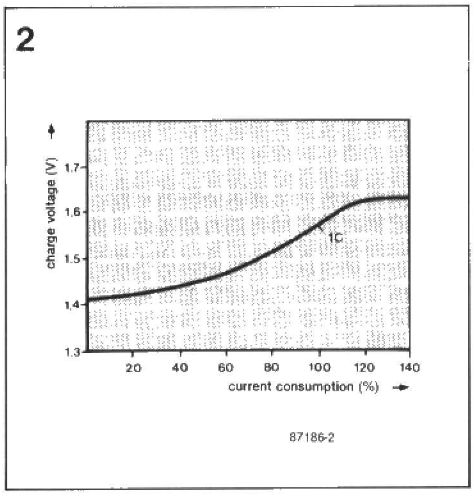


Fig. 2. Typical charging voltage vs charging current (as a percentage of battery capacity) characteristic of sintered NiCd cells for a charging current of 1C (=0.5 A for a 500 mAh battery). A charge of about 80% of full capacity is reached when the battery voltage has risen to just above 1.5 V.

about 4 hours playing time. If they had been charged to their full capacity of 500 mAh, they would have afforded 5 hours playing time.

To enable batteries to be charged to their full capacity, a resistor (dashed across the current source in Fig. 3b and Fig. 3c) may be fitted. This resistor allows a small charging current to continue to flow after the current source has switched off. During the fast charge, the resistor is virtually short-circuited by the darlington and is, therefore, of no practical consequence.

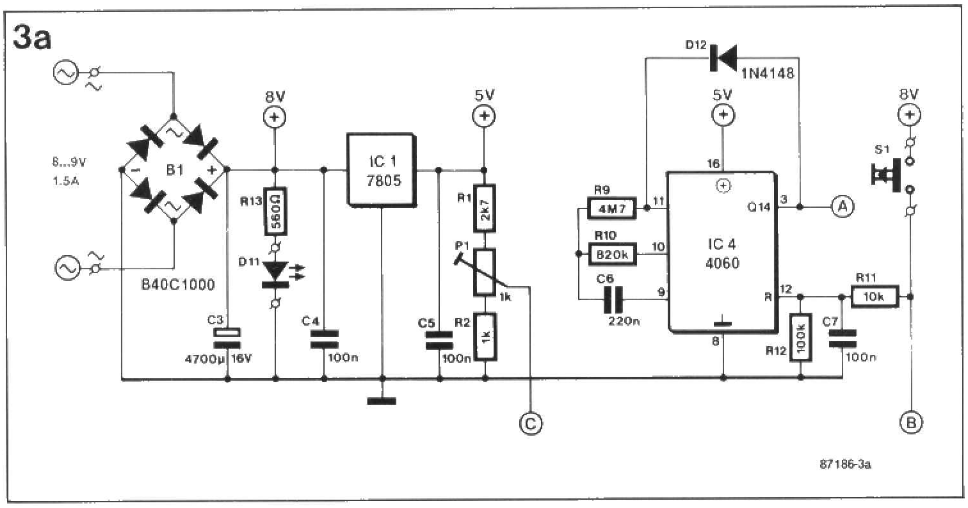
For a 'normal' charging current of 45-50 mA, the value of this resistor is 150R and rated at not less than 0.5 W, but 1 W is better. Normally, there is no risk in leaving the batteries on charge via this resistor for days on end. If this happens habitually, however, it is better to give the resistor a value of 220R or even 270R, rated at 0.5 W.

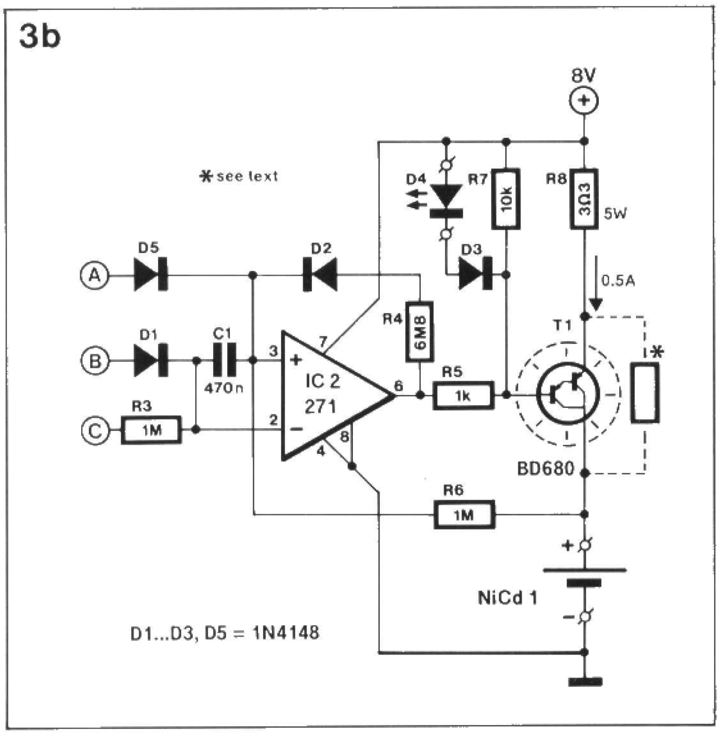
A reasonably charged battery can be kept at that level by giving the shunt resistor a value of 330R.

Finally

Although it was said earlier on that the supply is obtained via a mains transformer, it is also possible to obtain it from a mains adapter that gives an output of 8 V a.c. or d.c. (in the latter case, there is, of course, no need for the rectifier in Fig. 3a).

Darlingtons T_1 and T_2 require a heat sink.





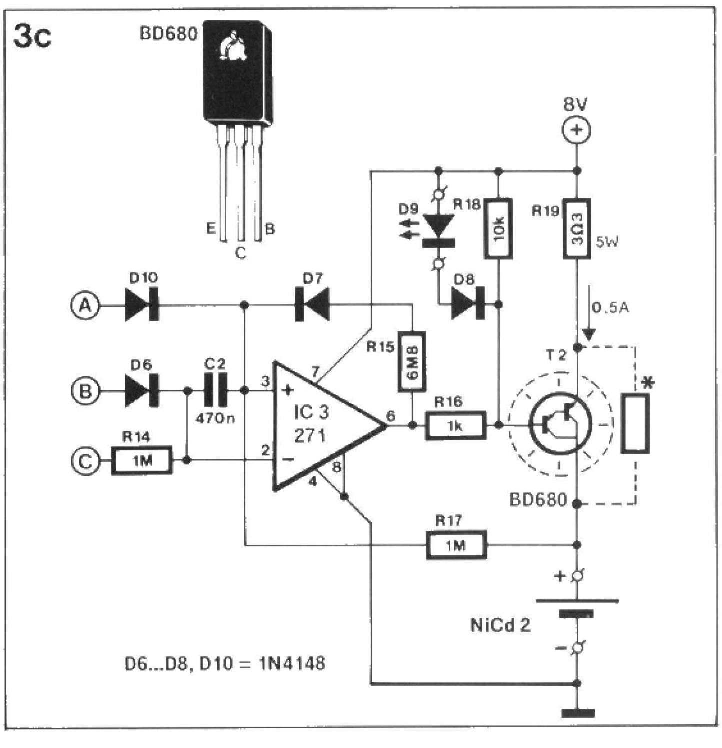


Fig. 3. The circuit diagram of the battery charger: if only one battery is required to be charged at any one time, the section in Fig. 3c may be omitted.

Parts list

Resistors (±5%):

R1 = 2K7
R2;R5;R16 = 1K0
R3;R6;R14;R17 = 1M0
R4;R15 = 6M8
R7;R11;R18 = 10K
R8;R19 = 3R3; 5 W
R9 = 4M7
R10 = 820K
R12 = 100K
R13 = 560R
P1 = 1K0 preset

Capacitors:

C1;C2 = 470n
C3 = 4700μ; 16 V
C4;C5;C7 = 100n
C6 = 220n

Semiconductors:

B1 = B40C1000 (40 V; 1 A) (Universal Semiconductor Devices)
D1;D2;D3;D5 . . . D8 incl.;D10;D12 = 1N4148
D4;D9 = red LED
D11 = green LED
IC1 = 7805
IC2;IC3 = TLC271CP (Cricklewood)
IC4 = 4060
T1;T2 = BD680 (Cricklewood)

Miscellaneous:

S1 = miniature SPST switch.
Heat-sink for T1; T2.
PCB Type 87186 (see Readers Services page).

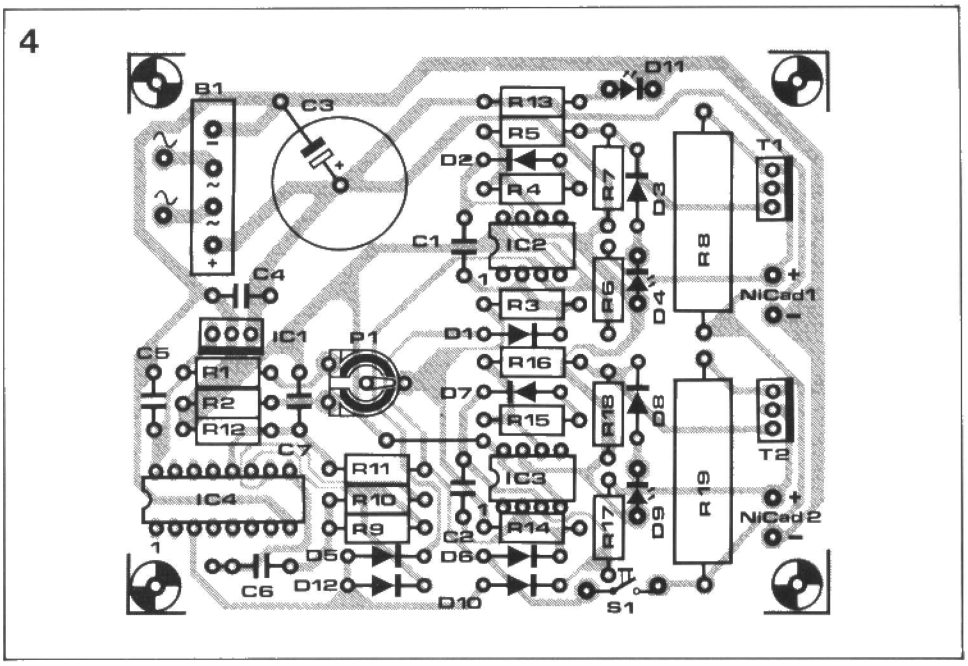


Fig. 4. The printed circuit of the battery charger.

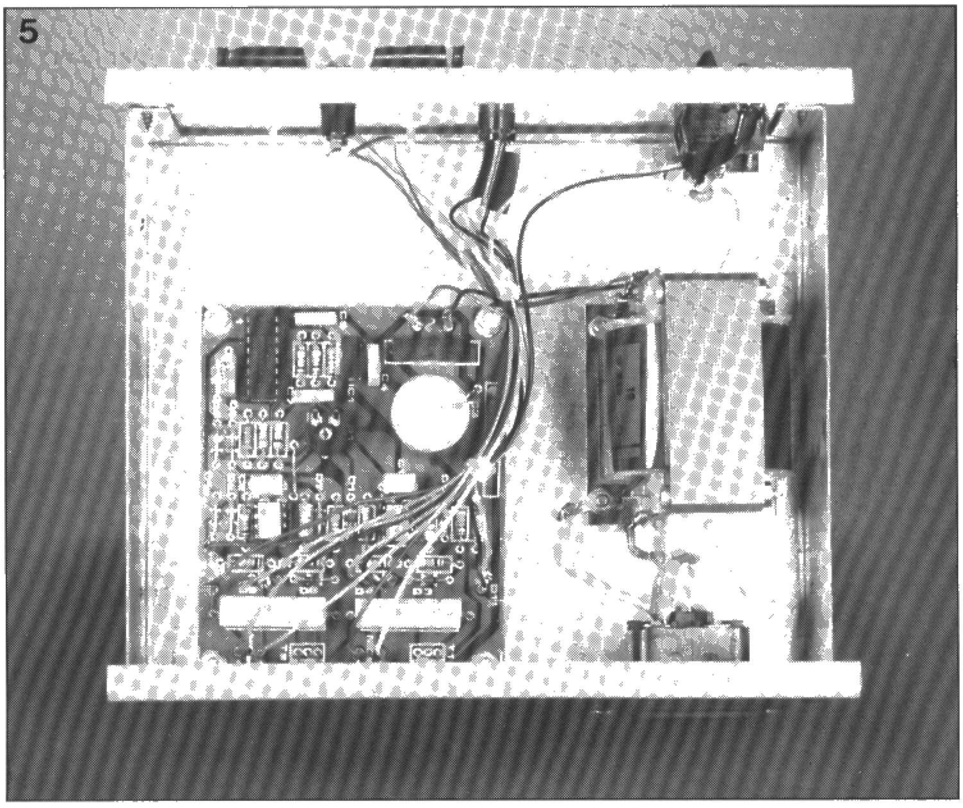


Fig. 5. Top inside view of the prototype of the battery charger.

If there is no need for charging two batteries simultaneously (some personal radios work from one 1.5 V battery), one of the sections in Fig. 3b or Fig. 3c can be omitted. In that case, the input current needs to be only about 0.7 A instead of 1.5 A.

The battery voltage varies from manufacturer to manufacturer, but lies normally around 1.5 V. During the first few charging cycles it is, therefore, recommended to set P1 to 1.5 V. Make sure that the batteries are fully discharged before connecting them to the charger, and ascertain (with the aid of D4 and D9) when the current sources switch off. The optimum charging period is about 55 minutes. If the current sources switch off after a shorter period, increase the reference voltage slightly. If the reference voltage was originally set too high, the timer will switch off the charger. The ideal situation is that the comparators switch off just before the timer can do so.

In all this, it is assumed that the ambient temperature remains at roughly the same level. At lower temperatures, the charger switches off slightly sooner; at higher temperatures, somewhat later.

Construction of the charger on the printed-circuit board should present no difficulties. After the board has been populated, it may be fitted, together with the mains transformer (if used), reset switch, lights, on/off switch, and battery connector in a neat enclosure as shown in Fig. 5.

It should be possible to construct the charger for about £15.00 (at UK prices: in other countries, this cost may be quite different).

A HIGH-SPEED DEPLETION-MODE DMOS FET FOR SMALL-SIGNAL APPLICATIONS

by Alan Pritchard

This article describes a new ultrahigh-speed n-channel depletion-mode lateral DMOS transistor geared for small-signal applications. This device boasts high-performance characteristics, which include tunr-on speeds of less than 1 ns; low reverse-transfer capacitance of less than 2.5 pF; high-frequency transconductance greater than 10 ms; a wide dynamic range; and low distortion.

Fig. 1a and 1b show idealized cross-sections of the 'normally-on' depletion mode and 'normally-off' enhancement-mode devices. Because these device structures are similar, the device characteristics are also similar. In fact, the depletion-mode device may be thought of as an enhancement-mode device with a negative threshold voltage.

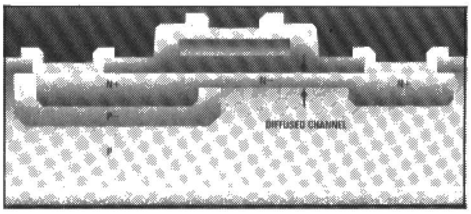


Fig. 1a. Depletion-mode device cross-section.

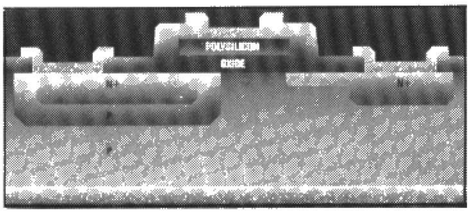


Fig. 1b. Enhancement-mode device cross-section.

Unlike enhancement-mode devices, whose drain current falls to zero when the gate-to-source voltage equals zero, the new depletion-mode FET has appreciable current at zero gate signal. In fact, the drain-to-source resistance is typically 100 Ω at zero voltage. As shown on Fig. 2, the on-resistance $r_{DS(on)}$ versus analogue signal range is an almost flat response. This characteristic, coupled with the low-capacitance values of the new device, makes it particularly suitable as an analogue switch for audio and video switching applications.

The depletion-mode 'normally-on' characteristic makes the FET useful for

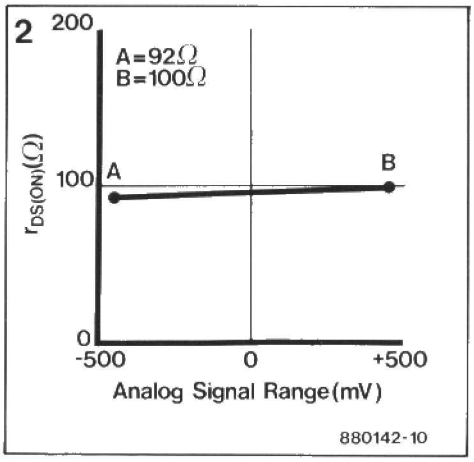


Fig. 2. On-resistance versus analogue signal range for the SD2100 depletion-mode DMOS FET.

single-device current regulators. This type of circuit, usually associated with junction FETs, is shown in Fig. 3. The value for Rs can be calculated from:

$$R_S = \frac{V_{GS(off)}\,[1-(I_D/I_{DSS})^{1/2}]}{I_D}$$

where I_D is the required value of regulated current.

The major advantage of depletion-mode MOSFETs in current-source circuits is

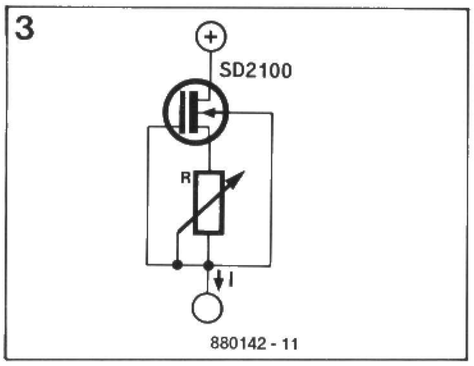


Fig. 3 Single-device current regulator.

their low drain capacitance, which makes them suitable for biasing applications in low-input leakage, medium-speed (>50 V/μs) circuits. Fig. 4 shows a low-input-leakage current differential front-end employing a dual low-leakage junction FET.

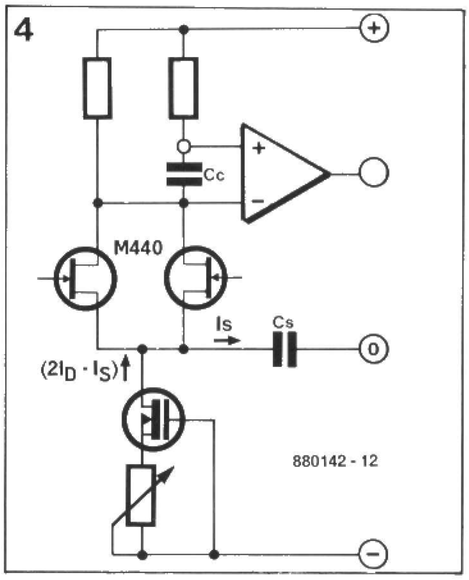


Fig. 4. Low bias-current differential front-end using an M440 OFET. Note C_s reduces the maximum current swing available to charge C_c, thus reducing the slew rate.

In general, each side of the JFET will be biased at $I_D = 500$ μA. Thus, the current available for charging compensation and stray capacitances is limited to $2I_D$ or, in this case, 1.0 mA. The JFET's matching characteristics are production-tested and guaranteed on the data sheet.

C_s represents the output capacitance of the input stage 'tail' current source. This capacitance is important in non-inverting amplifiers, because the input

stage undergoes considerable signal excursions in this connection, and the charging currents in C_s may be large. If standard current sources are used, this tail capacitance may be responsible for marked slew-rate degradation in non-inverting applications (as opposed to inverting applications, where the charging currents in C_s are very small).

The slew-rate reduction may be shown as:

$$\frac{1}{1 + (C_s/C_c)}$$

As long as C_s is small compared to C_c (the compensation capacitor), little change in slew rate occurs. Using the DMOS FET, C_s is about 2 pF. This approach yields a significant slew-rate improvement.

Where I_{DSS} currents greater than 1 to 5 mA are required, the device may be biased into the enhancement mode to produce up to 20 mA for a V_{GS} of +2.5 V maximum, with low output capacitance remaining a major feature. Fig. 5 shows a suitable enhancement-mode current source.

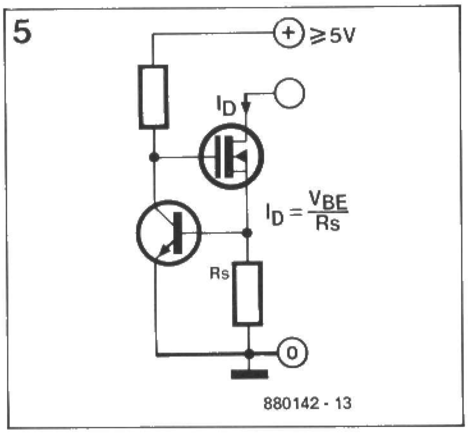


Fig. 5. Enhancement-mode current source.

A 'normally-on' analogue switch can be constructed for applications where default condition is required at supply failure, such as for automatic ranging of test equipment or for guaranteeing correct initialisation of logic circuits at start-up.

The low negative threshold voltage of the device gives simple drive requirements and allows low voltage operation. Fig. 6 shows the typical bias conditions for a depletion-mode DMOS analogue switch.

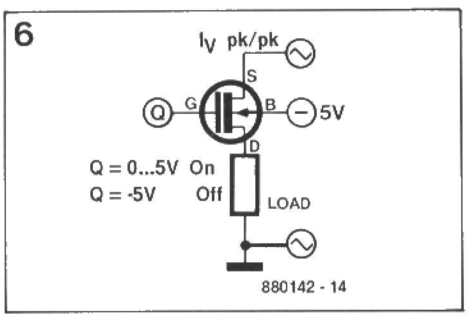


Fig. 6. 'Normally-on' analogue switch.

To turn the device off, a negative voltage is required on the gate. However, the on-resistance can be reduced if the device is further enhanced with a positive gate potential, allowing it to be used in the enhancement-mode region as well as in the depletion-mode region. This effect is shown in Fig. 7.

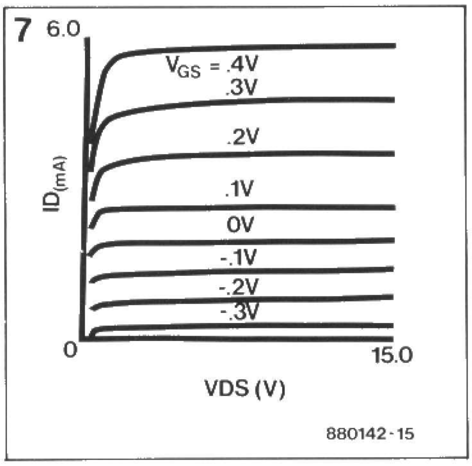


Fig. 7. Current versus drain-to-source voltage for the Siliconix SD2100 DMOS FET.

The high-frequency gain of the device, along with its low capacitance values, produces a high 'figure of merit'. This is an important factor in VHF and UHF amplification, and defines the gain-bandwidth product (GBW) of the device, which may be expressed as:

$$\mathrm{GBW} = \frac{g_{fs}}{2\pi(C_{in} + C_{out})} \quad (3)$$

For a common-source configured amplifier, this becomes:

$$\mathrm{GBW} = \frac{g_{fs}}{2\pi(C_{iss} + C_{rss})} \quad (4)$$

where:

C_{iss} = short-circuit input (Miller)capacitance = $C_{gs} + C_{dg}(1 - A_V)$;
C_{gs} = gate-source capacitance;
C_{dg} = feedback capacitance;
C_{rss} = short circuit reverse transfer capacitance = C_{dg}.

It is evident that the gain-bandwidth product is largely dependent on the device gain and the feedback capacitance. If typical values for the new DMOS FET are substituted in Eq. 4, including the low feedback capacitance of 2.5 pF, the gain-bandwidth product is found to be greater than 400 MHz, a useful value in VHF and UHF operation.

The high figure of merit is also reflected in the nanosecond turn-on times which are important in applications such as sync-pulse generation for high-definition video systems, signal routeing for high-speed digital video recording where data rates of greater than 100 Mbit/s are possible, and outside broadcasting systems where signal switching is required during blanking periods. Fig. 8 shows a high-performance video d.c. restorer. In these applications, the low distortion characteristics are important.

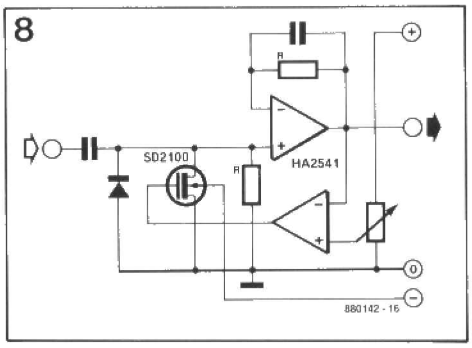


Fig. 8. High-performance video d.c. restorer using the SD2100.

The new device is also useful in applications that require both low charge injection and high switching speeds. For example, a 'de-glitch' circuit for the output of a high-speed digital-to-analogue (D/A) convertor, such as those found in video waveform generators, can take advantage of the device's high speed, low capacitance, and low distortion.

Glitches at the D/A convertor output, as shown in Fig. 9, are generated during the switching transition times, when time skew allows incoming and previous data to overlap. The worst-case occurence is at MSB (most significant bit) switching (e.g. from 01111111 to 10000000).

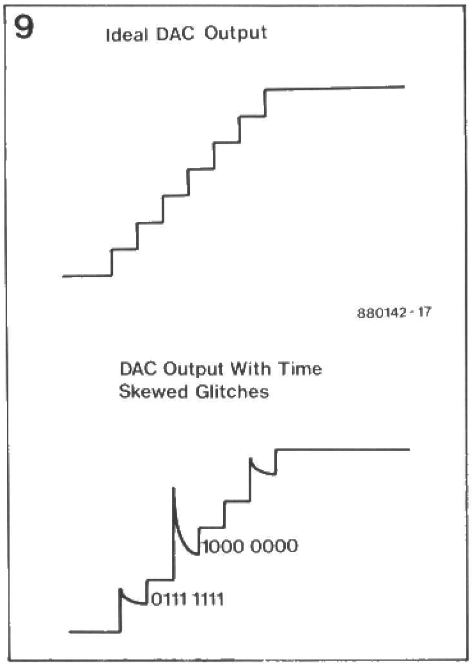


Fig. 9. Effect of time-skew glitches at D/A convertor output.

A de-glitch circuit effectively forms a sample-and hold function which

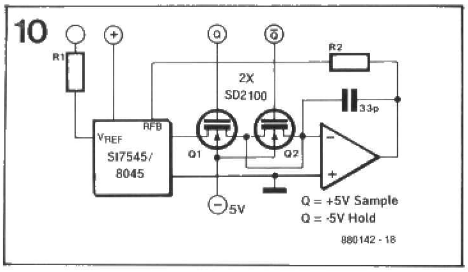


Fig. 10. 'De-glitched' D/A convertor using two SD2100 devices. Note: Charge injection is reduced by complementary drive to Q_1 and to Q_2, which acts as a 'dummy' capacitor.

samples the output some time after it has settled. As D/A convertor performance improves, settling times approaching 10 ns have become possible; therefore, fast-switching, low-capacitance sample-and-hold circuits, such as the one shown in Fig. 10, are required.

Alan Pritchard is with Siliconix.

NEW PRODUCTS

Compact disc cleaning system

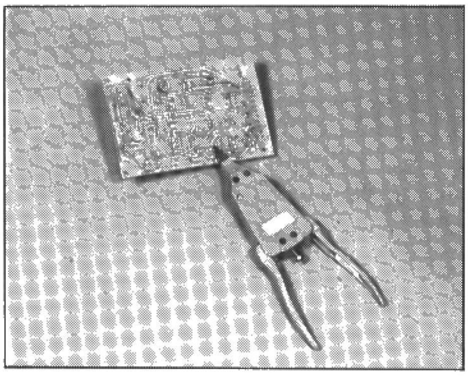
Although compact discs are considerably more robust than conventional records, they still need care and attention to maintain their high reproduction quality. Maplin Electronics have, therefore, introduced a new Compact Disc Cleaning System.

The system contains a special cleaning solution in a pump-action spray container, and a tray with hinged clear acrylic lid. The tray is fitted with a soft foam pad on to which the CD is placed lable down. After wetting the disc with spray, a velvet pad supplied in the tray is wiped across the disc to clean it thoroughly. Both the foam and velvet pads may then be cleaned with the brush also supplied in the tray.

The system, referenced YP45Y, is priced at £5.95 incl. VAT. It is available from Maplin's nationwide shops (see back cover) or by direct mail from Maplin Electronics • P.O. Box 3 • RAYLEIGH SS6 8LR.

Clean soldering

With the ever-increasing requirement for cleaner working conditions, both environmentally and in terms of production standards, X-42 low-residue cored solder wire should become a major contributor. X-42, manufactured by Multicore Solders Ltd, produces negligible fumes and residues, thus eliminating the necessity and cost of cleaning after soldering. It is available from Cirkit Distribution Ltd • Park Lane • BROXBOURNE EN10 7NQ • Telephone (0992) 444111 • Telex 22478 • FAX (0992) 464457.



Component-lead trimmer

Wybar Electronics have introduced a hand component-lead trimmer. This trimmer, the model TP3, cuts component lead legs after insertion into a PCB and bends the ends of the leads at a right angle at the same time to secure the component so that it will not be dislodged during hand or automatic soldering.

Wybar Electronics • Unit M • Portway Industrial Estate • ANDOVER SP10 3LU • Telephone (0264) 51347/8 • Telex 477291.

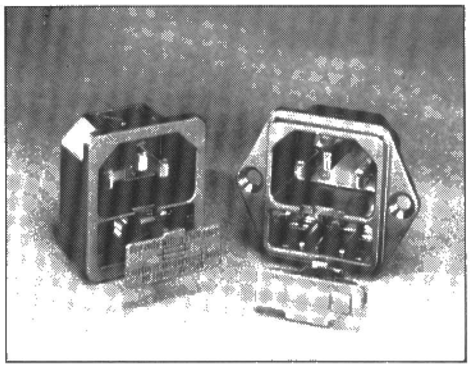
Shock-resistant multi-layer capacitors

To complement its already wide range of KEMET capacitors, STC Electronic Services has introduced the AXIMAX series dipped axial conformally-coated multi-layer ceramic capacitors.

Available in the range 10 pF to 0.47 μF, these components are encapsulated in a shock- and moisture-resistant epoxy coating which meets the requirements of Underwriters Laboratory Standard 94V-0.

STC Electronic Services • Edinburgh Way • HARLOW CM20 2DF • Telephone (0279) 626777.

Snap-in inlets with captive fuseholder



Rendar's 6200 Series snap-in mains inlets feature IEC-320 connectors and a captive fuseholder. The inlets couple high quality with very low installation costs and can be supplied to fit a wide range of panel gauges.

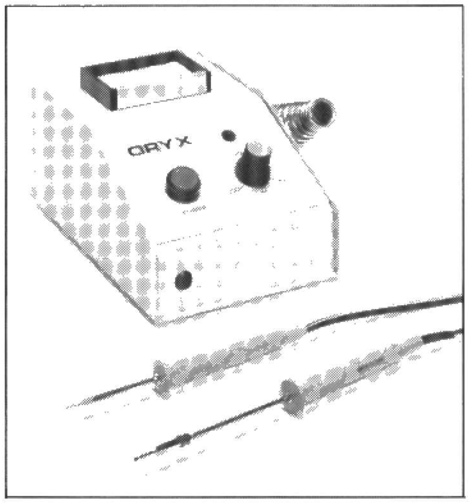
Rendar Ltd • Durban Road • South Bersted • BOGNOR REGIS PO22 9RL • Telephone (0243) 825811 • Telex 86420.

Battery charging adaptor

A new adaptor, the BCA-A1, will allow fast charging of many standard hand-held battery packs. It simply slides on to the top of the NiCd pack and allows any proprietary charger to be plugged into the adaptor's standard DC socket.

The adaptor is suitable for most of the Icom, Kenpro, CTE, and other hand-held transceivers.

Nevada • 189 London Road • PORTSMOUTH PO2 9AE • Telephone (0705) 662145 • Telex 869107 • FAX (0705) 690626.



Intricate soldering

To aid engineers who are working on close-density PCBs or Surface Mount boards, Greenwood Oryx have developed a new electronic temperature-controlled soldering station designated the MES24. The unit feeds a micro-miniature soldering iron rated at 12 watts with a choice of 9 tip configurations.

Greenwood Electronics • Portman Road • READING RG3 1NE • Telephone (0734) 595843 • Telex 848659.

PCB DESIGN ON THE BBC AND PC1512/1640 COMPUTERS

Many constructors shy away from building even the simplest circuit when a printed-circuit board, or the artwork for it, is not available, forgetting that there are now affordable computer programs that enable track layouts to be designed and edited on screen with various options available. The output of these programs is transferred to a printer or a plotter to obtain the required artwork that, in turn, can be used to produce a transparent film.

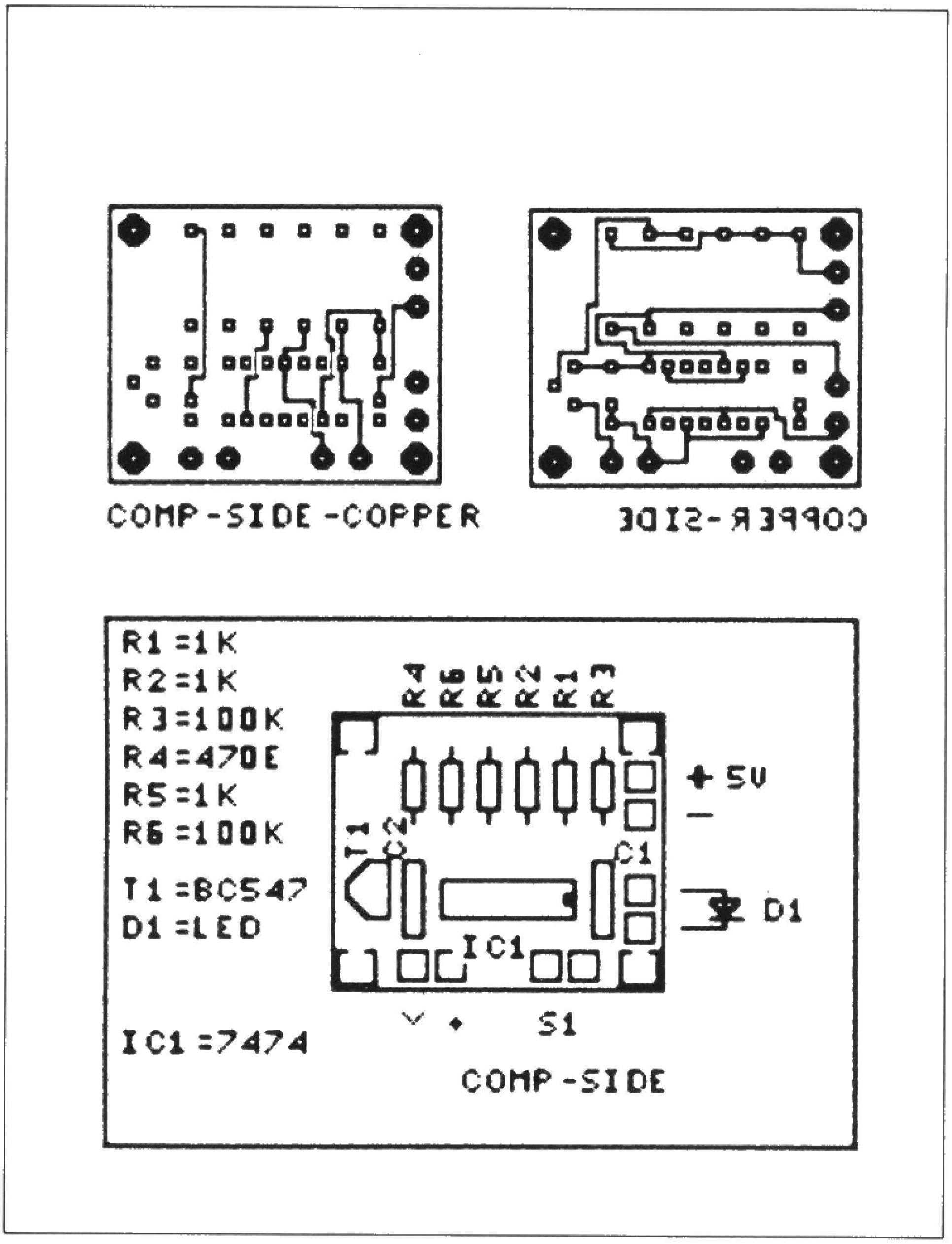
What was long considered the exclusive domain of professional engineering departments has now come within the reach of thousands of owners of home computers: computer assisted design (CAD) of printed circuit boards is now available at relatively low cost for a number of the most popular computers. This article introduces two PCB design packages:

- ***PCB*** for the BBC-B, B+ or Master with discdrive (Archimedes version also available);
- ***PC-B*** for the Amstrad PC1512 and PC1640.

PCB from Pineapple Software

The printed circuit board design package for the BBC series of computers comes as a 16 Kbyte ROM, a disk and a manual. An auto-routeing ROM, also 16 Kbyte, is available as an optional upgrade — more about this later.

PCB is a language ROM, the auto-router a service ROM. It is astonishing how the makers of *PCB*, J. Daniels and P. Rainger, have managed to squeeze such a vast amount of powerful software in the relatively small memory area available in the BBC computer. This is made possible by clever use of the sideways ROM area for the main program, in combination with the screen RAM for storing the track layouts. This leaves the system RAM in the computer free to hold parts of the component library, ASCII strings and up to 190 auto-routeing interconnections. The board is drawn full-size in video MODE 1, with different colours used for the tracks at the component and solder side. Because of the high definition of MODE 1, it is essential to use a medium- or high-resolution RGB monitor. For obvious reasons, Pineapple do not recommend the use of the UHF TV output.



Some 1:1 plots produced by *PCB* from Pineapple Software. The design is for a simple key debounce and LED driver circuit, and was plotted with an Epson LX80 matrix printer (the resolution is not optimum due a worn-out printer ribbon).

Components are first loaded from a library, which, unfortunately, can not be extended. Next, they are dropped onto the grid at a suitable location selected with the aid of the cursor keys (or the mouse in the case of the Archimedes). With the same keys, components can be picked up and moved across the PCB plane, which has a maximum size of about 20 cm × 14 cm. Many components, but also roundels and tracks, are available in a variety of sizes, and the circle drawing and flood fill facility makes it possible to use round enclosures. Connectors of many sizes and shapes can be drawn likewise.

When all the components are placed, it is time to start identifying them with the aid of ASCII characters. Next, the tracks are drawn with reference to the circuit diagram either manually or automatically with the auto-router. In both modes, an auto-justify facility is available. This trims the tracks with great precision, and thus avoids messy lay-outs and short-circuits. Used with care, the auto-justify technique is invaluable for through-roundel or through-track connections, as used, for instance, for computer buses and connectors with 0.1 in spaced pins.

Sections of the PCB designed so far can be copied and stored on disk for use later. This is particularly useful for areas with a relatively complex track layout, e.g. a bank of memory chips.

The optional auto-router of *PCB* is one of the best and most versatile we have seen in its price class. All the designer has to do is look up the pin connections in the circuit diagram, locate the relevant roundels on the layout on screen, and connect them with a yellow 'rubber band', which is simply a straight line right across all other components on the board. In this way, a 'rats nest' of up to 190 connections is made before the auto-router is set to work on it to translate the pin connections into actual tracks, with a number of options available. The auto-router can be seen to work on screen, is relatively fast (typically 2—3 minutes for 50 tracks), and allows the user to manually draw a track when a particular connection can not be found. At this stage, the auto-router can be run a second time with different options, until a satisfactory result is obtained.

Then, it is plotting time. *PCB* can produce 1:1 and 2:1 artwork to an accuracy of 0.5% depending on the matrix printer used (Epson mode: quadruple density). The component overlay, track side, component side and solder resist mask can each be printed either positive or negative (flipped/reflected). An optional plotter disk is available with drivers for commonly used plotters including the Epson HI-80, Plotmate-M, Tandy, and those that accept commands to the HP-GL standard.

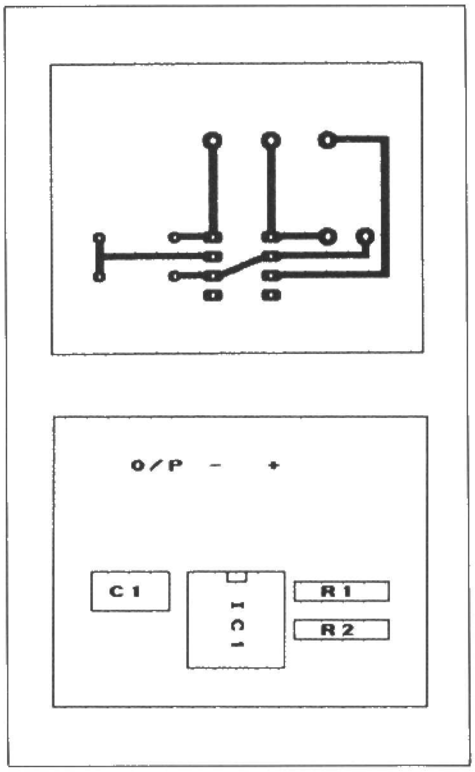
PCB is supplied with a neatly typeset, comprehensive 35-page manual. One of the strong points of the program is that it is so straightforward in use as to obviate consulting the manual after having worked it a few times. Not a single bug or oddity was encountered during our testing of a review sample, and the start-up layout provided on disk proved invaluable for getting acquainted with the operation of the available functions.

A few minor criticisms of an otherwise superb program are mainly suggestions for upgrading it. On the Archimedes, *PCB* runs under the 6502 emulator mode, and is not particularly fast. A 'real' Archimedes version of the program would, of course, benefit immensely from this machine's large memory, extremely powerful video and number crunching facilities, which are even faster and more advanced than those offered by, say, an IBM AT fitted with an EGA card. Another suggestion would be to provide the program with an ASCII netlist input, so that drawings generated on other computers can be read, after conversion, by the auto-router. Finally, the fact that the components library can not be extended or modified may be a disadvantage to users who frequently use non-standard components.

With a dash: *PC-B* from Labcenter Electronics

This program for the popular Amstrad PC1512 and colour PC1640 (CM or ECD) is remarkable for its ease of use and fast screen handling. *PC-B* was used successfully used on a PC1640 SD (mode CDCOLOR, EGA compatible, 80-columns) and a CGA compatible monitor from Ericsson. We also managed to get it to run on a 10 MHz turbo PC-XT compatible with an EGA card, after installing mouse driver version 7.01 for the Genius GM6 mouse. For reasons unknown, *PC-B* did not work properly in conjunction with mouse driver version 6.0. It should be noted here that the makers of *PC-B* explicitly do not guarantee that the program can be used on machines other than the above Amstrad types. The experiment with the PC-XT was interesting in itself but will not, therefore, be used to judge the performance of *PC-B*.

The package can be used on single, double and hard disk based machines. A monochrome option is available for the PC1512, but this can not, of course, guarantee a clear distinction between the 3 planes *PC-B* provides: component side, solder side and component overlay. *PC-B* is completely mouse and icon-driven, has a message screen and zoom facilities. While placing the components, orientation on the board is not easily lost because it is always visible in reduced size in the top right-hand corner



1:1 plots of the sample layout provided by Labcenter on the *PC-B* disk. Plotted on a matrix printer Type M1509 from Brother. The circuit is a basic application of the well-known Type 555 timer chip.

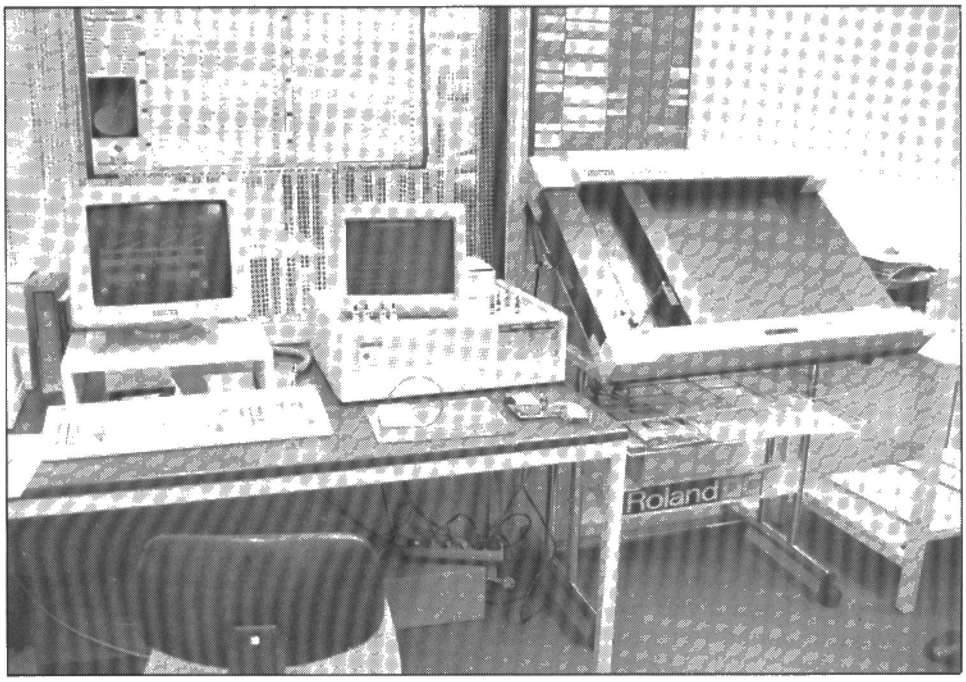
of the screen. There are no difficult to follow menus or sub-menus with confusing options: all that is needed is to move the mouse and click the buttons where and when appropriate. The keyboard is used only for typing in component references, and for selecting options when the plot program is run.

A basic component library is provided in the file PCB.LIB on the disk. Among the most commonly used components in various styles and sizes we were surprised to find the Type LM016L LC display, which has been used a number of times in *Elektor Electronics* projects. The components library can be accessed to create new items fairly easily.

The so-called box functions of *PC-B* allow areas to be copied, moved and deleted by dragging a box around them. For the copy and move operations, a reference and destination mark is entered to obtain the correct orientation of the new area.

PC-B does not have an auto-routeing facility, so that all tracks must be drawn manually. It provides auto-justification and another useful design aid, auto-overlapping, to ensure that right-angle bends in tracks are square.

Both 1:1 and 2:1 plots of the layouts can be made with Epson compatible matrix printers, as well as the Epson HI-80 plotter (other plotters can be supported on request — Labcenter needed only a few days to provide us with a driver for our Roland plotter). Various options are available for plotting on matrix printers, including print density and single-sheet.



A look in *Elektor Electronics's* PCB design department. For some applications, particularly RF and size-critical projects, manual taping is still the only way to obtain a high-quality PCB, although we make increasing use of recently installed CAD equipment. The Ultiboard PCB design system shown is an AT-compatible PC that reads ASCII netlist files produced by a schematics drawing program, ORCAD. The computer allows board layouts to be designed and optimized overnight. Once the results are satisfactory, plotting is effected on to transparent film at scale 2:1 on a Roland Type DPX2200 HP-GL compatible flat-bed A2 plotter with electrostatic paperholder.

It is not quite clear why the actual plotter routines and drivers are not integrated in the menu of the main program. When a layout is finished on screen, the menu allows a plot file called PLOT.DAT to be generated and stored on disk. The user is then forced to exit *PC-B*, and, at the DOS level, run the appropriate printer or plotter driver (this automatically loads PLOT.DAT). After answering a number of prompts, plotting starts. No provision has been made to redirect the plotter output from LPT1: (standard parallel printer output).

Configuring *PC-B* may be somewhat difficult for those unfamiliar with MSDOS in general and configuration files in particular. Although these can be made fairly rapidly with any text editor that can produce ASCII files, it is necessary to look up and closely follow the relevant information on syntax, screen colours, files, paths and memory allocations set out in the manual (Appendix 1: Configuration File). This procedure could have been simplified considerably by adding a menu-driven setup program that, after exitting, updates the PCB.CFG file so that this contains the user's parameters.

Labcenter offer a unique plotting service to users of *PC-B*. At a basic charge of £1.50 for a single plot, £0.50 extra for a plot on transparent film, and £0.50 for postage & packing, they load plot files from a user-supplied disk, and send these to their Epson HI-80 4-colour A4 plotter. This service should appeal to all users who, after finishing a design, need a high-quality transparent film because the resolution offered by their dot matrix printer is considered too low.

In conclusion, *PC-B* is excellent value for money. The documentation supplied with the program is concise but complete, and program updates are available to licenced users. Needless to say that an auto-routeing option would be a very welcome addition to the program.

General conclusions

The packages reviewed here prove that low-cost computer-assisted PCB design has arrived, and is here to stay. Obviously, the main task of PCB design programmers is to ensure that operation is as simple as possible, and this is where both Pineapple Software and Labcenter Electronics have succeeded very well.
Hopefully, the price of plotters comes down to an acceptable level, and auto-routeing will be provided or improved further by the addition of an ASCII netlist input. When the PCB design package is considered to sit between *input* in the form of a netlist file, and *output* in the form of a set of plotter commands, it is important to realize that there exists, at present, no single standard for the syntax and structure of either of these.

PRICES AND AVAILABILITY

PCB for the BBC-B, Master and Archimedes (emulator mode):

Manual *PCB* program:	£85.00
Full auto-route package:	£185.00
Auto-route ROM upgrade	£110.00
Plotter driver disk	£35.00

Prices are exclusive of VAT, but inclusive of postage & packing
Pineapple Software • 39 Brownlea Gardens • Seven Kings • Ilford • Essex IG3 9NL. Telephone: (01 599) 1476.

PC-B for the Amstrad PC1512 and PC1640 costs £80.00 incl. of VAT; A demo version is available for £2.00.
Labcenter Electronics • 14 Marriner's Drive • Heaton • Bradford BD9 4JT. Telephone: (0274) 542868.

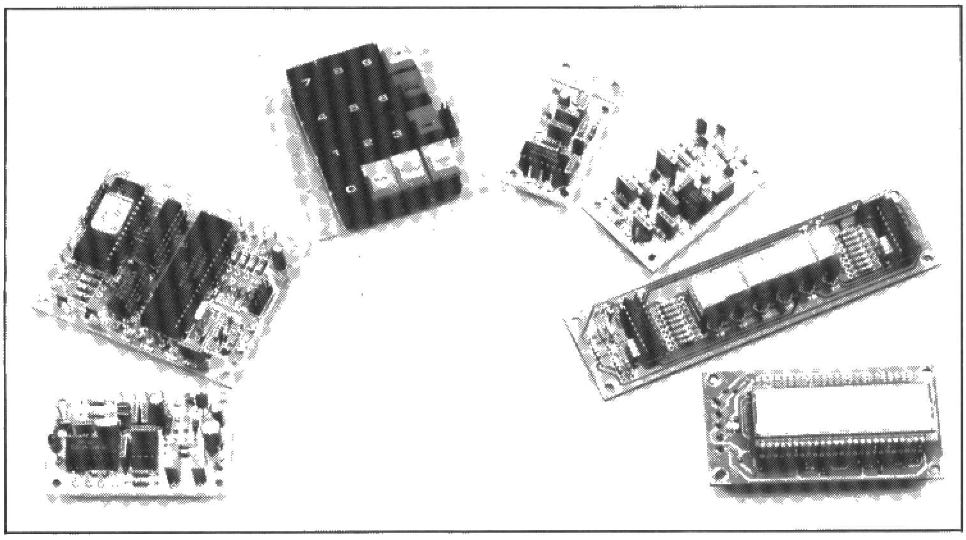
MICROPROCESSOR-CONTROLLED RADIO SYNTHESIZER — 2

by Peter Topping

This final instalment of the article deals with the construction and setting up of the multi-purpose RF synthesizer. This has been divided in a number of building blocks to allow its use in a large number of applications, from upgrading surplus SW receivers to providing state-of-the-art tuning on modern tunerheads for the VHF FM band.

It will have been evident from Part 1 of this article [1] that the microprocessor-controlled synthesizer is a relatively complex project with many possible configurations and applications. To enable its use with many types of receiver (SW, SW/MW, VHF FM), and to allow the user the choice between three types of display, the synthesizer system is divided in a number of sub-units:

1. Microprocessor board;
2. Keypad;
3. One or more displays (these are not necessarily of the same type);
4. Power supply;
5. Synthesizer board;
6. VHF prescaler board (f_{LO} up to 150 MHz);
7. SW prescaler board (f_{LO} up to 40 MHz).



Prototypes of all boards, completed and ready for wiring. From the left to the right: Synthesizer, microprocessor, keyboard, SW prescaler, VHF prescaler, LED display, LCD display.

Items 1, 2, 3 and 4 are fitted in a separate enclosure, while 5 and 6, 5 and 7, or 5 and 6 and 7, are incorporated in the existing receiver. Item 4, the power supply for the microprocessor/display unit, is not discussed here as it assumed that the constructor is capable of building a simple regulated 5 VDC power supply without the need for repeating an application of the 7805. Similarly, the 5 V supply for items 5, 6 and 7 should be relatively simple to obtain from the receiver.

As already noted in Part 1, the supply voltage for the opamp in the synthesizer module (Fig. 3) is governed by the maximum reverse voltage required on the varicap that tunes the local oscillator. Remember that this auxiliary voltage is also applied to varicaps D_1 and D_2 in the RIT circuit, so that it must remain below +10 V. Where +30 V is to be used, make sure that this is **only** applied to C_{11} and IC_2.

Prescalers

The circuit diagram of the prescaler for SW receivers is shown in Fig. 8. Transistor T_{11} ensures that the local oscillator in the receiver is not excessively loaded, and at the same time functions as an amplifier/digital driver for divider IC_{12}. The prescaler has a divide-by-five and a divide-by-ten output (refer to Table 1 in Part 1). It can handle LO input signals of up to about 40 MHz, and has a sensitivity of 150 mV_{rms} at 20 MHz. The maximum usable frequency can be increased to over 60 MHz by using a Type 74F90 in position IC_{12}.

The VHF prescaler is a rather more elaborate circuit — see Fig. 9. Ahead of the divide-by-ten ECL counter, IC_{13}, is a two-stage direct-coupled wideband amplifier, T_8-T_9. Although the SP8660 is stated to have a TTL- and CMOS compatible open collector output, some interfacing and filtering of the signal is required before it can be applied to the LO input of the MC145157 (IC_1). Sensitivity of the VHF prescaler decreases from 30 mV_{rms} at about 100 MHz to 500 mV_{rms} at 190 MHz (note that the latter frequency exceeds the maximum specification of the SP8660). In an experimental set-up, the VHF prescaler was found to have an abolute maximum

Corrigenda to Part 1:

- Pull-up resistor R_{40} (Fig. 4) should be labelled R_{70}.
- The IF offset table in the EPROM starts at $19DB_H$, not $1E05_H$.
- R_9 (Fig. 3) is a 3K9 resistor.
- Pin 11 of IC_{11} should be connected to ground.

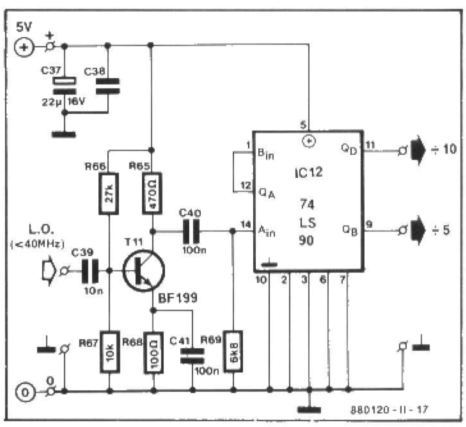


Fig. 8. Circuit diagram of the 40 MHz prescaler with divide-by-five and divide-by-ten outputs for use with SW receivers.

input frequency of 250 MHz. The amplification of T_9 is defined mainly by the value of R_{58}.

Five modules on one PCB

Printed circuit board 880120 (Fig. 10) is quite large because it holds the following sub-units (the associated circuit diagrams are given in parentheses):

- Synthesizer (Fig. 3);
- Microprocessor circuit (Fig. 4);
- Keyboard (in upper left-hand corner of Fig. 4);
- SW prescaler (Fig. 8);
- VHF prescaler (Fig. 9).

With the exception of the section for the keyboard, the PCB is double-sided, but not through-plated. The prescaler and synthesizer boards have large pretinned copper earth planes at the component side to prevent stray radiation.

Commence the construction with carefully cutting the large PCB in six to obtain the previously mentioned boards.

Microprocessor board:

The construction of the microprocessor board is not difficult, but should be done strictly in the order given below to avoid difficulties caused by the absence of through-plating (this was not used here to keep the cost of the PCB within limits). Through-contacting of tracks at the component and solder side of the board is effected by soldering the relevant component terminals or pins of IC sockets at both sides of the board.

Start by fitting the 40-way socket for the microprocessor, IC_3. A normal IC socket will not be very useful here since it does not allow soldering to tracks at the component side. Two 20-way terminal strips, or a 40-way wire-wrap socket, are suitable alternatives. A similar way of mounting applies to the other three ICs: first mount the socket for the 74HC373 (IC_4), then that for the 74HC00 (IC_6) and, lastly, that for the EPROM 27C64 (IC_5). Constructors with lots of confidence may, of course, solder all ICs direct on to the board, but this will make their removal at later stage very difficult.

Now fit the passive components, starting with the eight 100 kΩ pull-down resistors R_{19} to R_{26}, which are mounted vertically and commoned at the top side by a horizontal running ground wire (alternatively, use a 9-pin SIL resistor array).

In a number of cases, one or both terminals of a component will have to be soldered at both sides of the board to connect tracks. At the component side, some terminals run quite close to, or over, tracks they should not be connected to. To avoid short-circuits, bend the wires accurately, and mount components slightly above the board surface. The mounting of the 4 diodes and the quartz crystal (two possible enclosure sizes are allowed) should not present problems.

The connection of the microprocessor-board to the keyboard is made in a 10-way flat ribbon cable, terminated in 10-way press-on (IDC) sockets at either end for pushing on associated headers on the boards. The pinning of the connection is given in Table 3. All other connections to the microprocessor board are made via solder terminals.

Before mounting the ICs in their sockets, carefully inspect the microprocessor board for solder faults and/or short-circuits.

Synthesizer board:

No through-contacting is required here, with the exception of the three solder terminals for the ground connections (supply, LO input, LO TUNE output). The board is relatively densely populated, but its completion should not present problems. A few hints, though: do not use a socket for IC_1; the type indication printed on varicap diodes D_1-D_2 should face the quartz crystal.

SW prescaler board:

Solder IC_{12} direct on to the board. The terminals for the input and output coax cables are soldered at both sides of the PCB.

VHF prescaler board:

First, wind L_2 and L_3 as 6 turns of 0.2 mm dia (SWG36) enamelled copper wire through 3 mm long ferrite beads. When mounting these chokes, make sure that the copper wire can not touch the earth plane at the component side of the PCB. Next, mount the soldering ter-

9

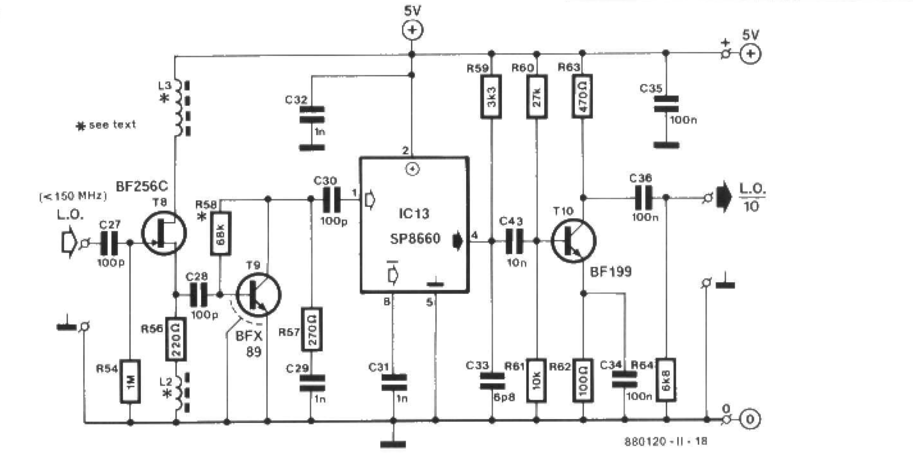


Fig. 9. The VHF prescaler is composed of a two-stage preamplifier, an ECL decade counter and a digital interface.

```
            *
            ************************************************
            *                                              *
            *    The IF offset is selected according to    *
            *    the required band, then placed in "P"     *
            *                                              *
            ************************************************

19B6 CD 19 34            IFO      JSR    BAND      FIND BAND
19B9 48                           LSLA             X2
19BA B7 22                        STA    WI
19BC 48                           LSLA             X4
19BD BB 22                        ADD    WI        TIMES 6 AND ADD 5
19BF AB 05                        ADD    #5        TO REACH LAST DIGIT
19C1 B7 23                        STA    W2        OF SELECTED IF
19C3 A6 06                        LDA    #6
19C5 B7 2A                        STA    COUNT
19C7 BE 23               LP6      LDX    W2
19C9 D6 19 DB                     LDA    IFS,X     TRANSFER
19CC 3A 23                        DEC    W2        SELECTED
19CE BE 2A                        LDX    COUNT     INTERMEDIATE FREQUENCY
19D0 E7 15                        STA    P-1,X     INTO P
19D2 3A 2A                        DEC    COUNT
19D4 26 F1                        BNE    LP6       DONE?
19D6 AE 16                        LDX    #P        SET-UP POINTER
19D8 BF 2C                        STX    NUM2
19DA 81                           RTS

19DB 00 00 00 04 05 05   IFS      FCB    0,0,0,4,5,5   455 KHZ SW/MW
19E1 00 00 00 04 06 08            FCB    0,0,0,4,6,8   468  "    "
19E7 00 00 00 04 07 00            FCB    0,0,0,4,7,0   470  "    "
19ED 00 01 00 07 00 00            FCB    0,1,0,7,0,0   +10.7 MHZ SW (EXT/5)
19F3 09 09 08 09 03 00            FCB    9,9,8,9,3,0   -10.7  "  FM (EXT/10
19F9 00 00 00 00 00 00            FCB    0,0,0,0,0,0      0  "   "      "
19FF 09 09 09 09 09 03            FCB    9,9,9,9,9,3   -70 KHZ    "      "
1A05 00 00 01 00 07 00            FCB    0,0,1,0,7,0   +10.7 MHZ "       "
                  *

                                                       880120 - II - L
```

Extract of the source listing used for assembling the machine code in EPROM IC_5. This routine reads the band selection switches and calculates the IF offset with the aid of the data between addresses 19DB and 1A0A.

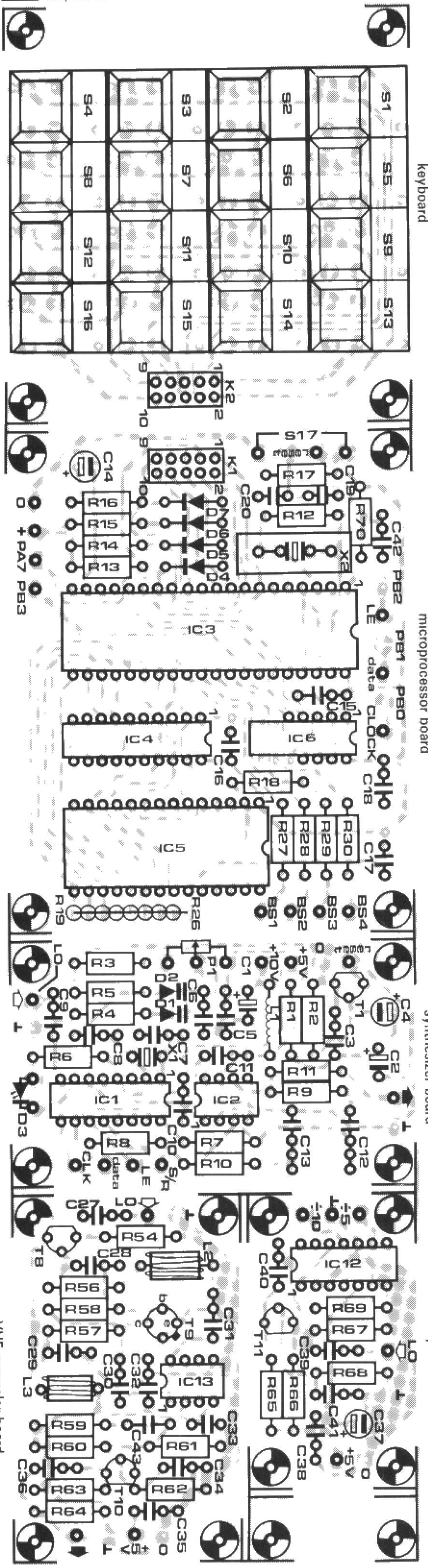


Fig. 10. Component mounting plan for pretinned, double-sided, not through-plated PCB 880120-1. This should be cut to separate (from top to bottom): keyboard PCB, microprocessor PCB, synthesizer PCB, VHF prescaler (lower left) and SW prescaler (lower right).

11

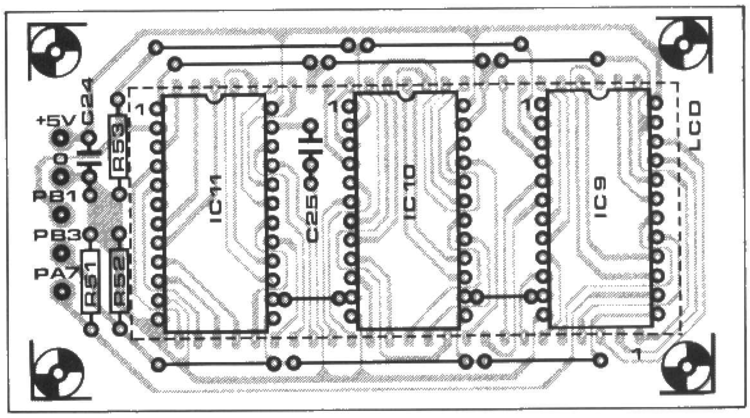


Fig. 11. Track layout and component mounting plan of the static LC display board. READ THE TEXT BEFORE FITTING THE LCD.

12

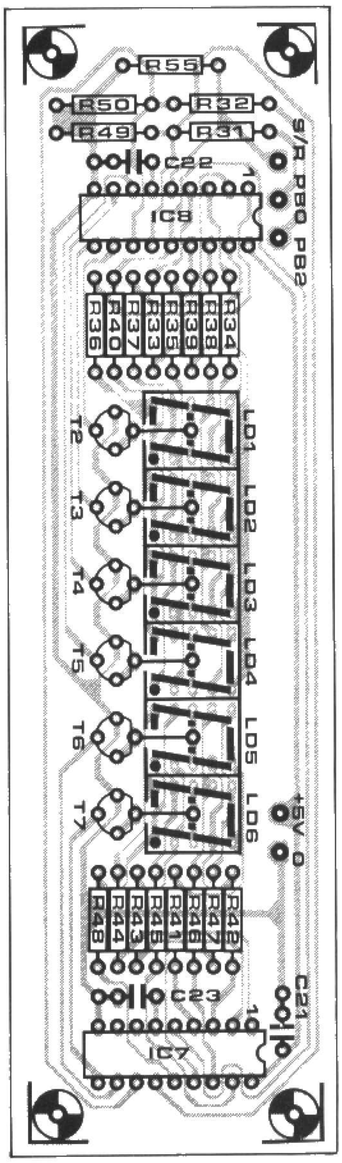


Fig. 12. Track layout and component mounting plan of the LED display board.

Table 3.

pin assignment on keyboard connectors:

K1	K2	Signal
1	1	KB7
2	2	KB6
3	3	KB0
4	4	KB1
5&6	5&6	KB5
7	7	KB2
8	8&10	KB4
9	9	KB3

Parts list

KEYBOARD

S1 . . . S16 incl. = Digitast momentary action key (ITT Schadow or ITW).
K2 = 10-way straight header; 2×5 pins in 0.1 in raster.

MICROPROCESSOR BOARD

Resistors (±5%):
R12 = 10M
R13 . . . R17 incl. = 10K
R18 . . . R30 incl. = 100K
R70 = 27K

Capacitors:
C14 = 10µ; 16 V; radial
C15 . . . C18 incl. = 100n
C19;C20 = 39p
C42 = 10n

Semiconductors:
D4 . . . D7 incl. = 1N4148
IC3 = MC146805E2 (Motorola; UK distributors are listed on InfoCard 507; *EE* April 1987).
IC4 = 74HC373
IC5 = programmed EPROM Type 27C64; order no. ESS 565 (see Readers Services page).
IC6 = 74HC00

Miscellaneous:
K1 = 10-way straight header; 2×5 pins in 0.1 in raster.
X2 = quartz crystal 1 MHz.
S17 = externally fitted push-to-make button.
S18 . . . S21 incl. = externally fitted miniature toggle switch.

SYNTHESIZER BOARD

Resistors (±5%):
R1 = 10K
R2 = 100K
R3 = 68K
R4;R5 = 1M0
R6 = 270R
R7 = 24K*
R8 = 39K*
R9 = 3K9*
R10 = 2K7*
R11 = 6K8*
P1 = externally fitted 100K linear potentiometer.
* See text.

Capacitors:
C1 = 47µ; 35 V; tantalum bead
C2;C3 = *not fitted*
C4 = 2µ2; 16 V; radial
C5;C9 = 100n
C6;C10;C11 = 10n
C7;C8 = 1n0 ceramic
C12;C13 = 1µ0; MKT

Semiconductors:
D1;D2 = KV1235Z (Toko product; available from Cirkit plc or Bonex Ltd. These diodes are sometimes supplied in sets of three matched devices held together as a Chocobreak® unit).
D3 = externally fitted red LED
IC1 = MC145157 (Motorola)
IC2 = 741
T1 = BC547B

Inductor:
L1 = 22µH axial choke.

Miscellaneous:
X1 = 10 MHz quartz crystal.

VHF PRESCALER

Resistors (±5%):
R54 = 1M0
R56 = 220R
R57 = 270R
R58 = 68K*
R59 = 3K3
R60 = 27K
R61 = 10K
R62 = 100R
R63 = 470R
R64 = 6K8

Capacitors:
C27;C28;C30 = 100p
C29;C31;C32 = 1n0
C33 = 6p8
C34;C35;C36 = 100n
C43 = 10n

Inductors:
L2;L3 = 6 turns 0.2 mm dia enamelled copper wire through a 3 mm long ferrite bead.

Semiconductors:
IC13 = SP8660 (Plessey; listed by Universal Semiconductor Devices)
T8 = BF256C
T9 = BFX89 (Cricklewood)
T10 = BF199

Resistors (±5%):
R65 = 470R
R66 = 27K
R67 = 10K
R68 = 100R
R69 = 6K8

Capacitors:
C37 = 22µ; 16 V; radial
C38;C40;C41 = 100n
C39 = 10n

Semiconductors:
IC12 = 74LS90
T11 = BF199

ALL OF THE ABOVE CIRCUITS ARE FITTED ON THE RELEVANT SUB-PCBs CUT OFF FROM TYPE 880120-1 WHICH IS AVAILABLE READY-MADE THROUGH THE READERS SERVICES.

STATIC LC DISPLAY BOARD

Resistors (±5%):
R51;R52;R53 = 100K

Capacitors:
C24 = 100n
C25 = 10n

Semiconductors:
IC9;IC10;IC11 = MC144115P (Motorola)
LCD = general-purpose 6-digit static liquid crystal display, e.g. Type LTD229-R12 (Philips Components), RS587-327 (RS Electronics), order no. 588-601 (ElectroMail), or order no. 257-37473B (VeroSpeed).

Miscellaneous:
PCB Type 880120-2 (see Readers Services page).

LED DISPLAY BOARD

Resistors (±5%):
R31;R32 = 27K
R49;R50;R55 = 100K
R33 . . . R48 incl. = 270R*
* See text.

Capacitors:
C21 = 100n
C22;C23 = 22n

Semiconductors:
IC7;IC8 = MC14499P (Motorola)
LD1 . . . LD6 incl. = HD1107R (Siemens; ElectroValue 0784 33603 or 061 432 4945)
T2 . . . T7 incl. = BC182

Miscellaneous:
S22 = externally fitted miniature SPST switch (see text).
PCB Type 880120-3 (see Readers Services page).

minals (three ground posts are soldered at both sides of the PCB). Proceed with fitting the resistors and capacitors, followed by the transistors. Lastly, solder the prescaler chip direct on to the board.

Keyboard:
The construction of this unit is so simple as obviate the need for further discussion.

Multiplexed display board:
As already stated in Part 1, this unit is not supported by a ready-made PCB because the multiplexed LC display is a relatively hard to obtain item. Constructors in possession of the Type 4200-365-920 from Hamlin may mount it on a piece of Veroboard, together with the three passive components and the display controller Type MC145000. As there are relatively few connections to be made (compare the circuit diagram, Fig. 7, to that of the static LC display unit, Fig. 6), the actual construction should not prove too difficult. When using the multiplexed display, be sure to fit it in a metal enclosure to reduce stray radiation.

LED and static LC display

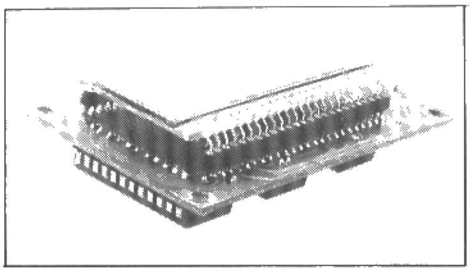
The single-sided printed circuit board for the static LC display is shown in Fig. 11. This is a very compact unit, whose construction is commenced with the mounting of the ten wire links, followed by the three 24-way IC sockets, five passive components and five

soldering pins.
THE DASHED LINES ON THE COMPONENT MOUNTING PLAN INDICATE THAT THE LIQUID CRYSTAL DISPLAY IS MOUNTED AT THE TRACK SIDE OF THE BOARD. BE EXTREMELY CAREFUL HANDLING THE FRAGILE GLASS DEVICE, AND MAKE SURE THAT IT IS FITTED THE RIGHT WAY AROUND.
Pin 1 of the LCD is practically opposite pin 13 of IC_9, as shown on the component overlay. Hold the display slightly oblique in clear light to make the individual segments visible. Turn the display so that the row of decimal points is horizontal and towards you. Pin 1 of the unit is the leftmost terminal, below the lowest horizontal segment of the first (most-significant) digit. The above description is given because not all 6-digit LC displays have a marker for pin 1.
The socket for the 50-pin LC display can be made from the terminal strips of a 40-way and a 14- or 16-way IC socket. Mount these strips slightly above the board surface to enable soldering to the tracks. Then fit the display carefully, observing the previously mentioned orientation. Be sure that the display is supplied with side pins, so that it can be mounted as an integrated circuit.

Constructors opting for a 7-segment LED display should have little difficulty completing the printed circuit board shown in Fig. 12. First fit the 6 wire links, then the sockets for the displays (cut off 14-way IC sockets to make your own 10-way types).

Initial test

Make all the necessary connections between the completed microprocessor board, synthesizer board, keyboard and the static LCD or LED display. The prescalers are not required as yet. Do not forget to temporarily connect the reset switch and band/I.F. switches to the microprocessor board, and be sure to observe the terminal designations printed on the PCBs. Note that the LED display board is driven with the $\overline{S}$/R signal provided by the synthesizer board via an optional switch, S_{22} (see Part 1).
It is recommended to power all the units from a single 5 V supply. Where a separate 10 V supply is not available, connect the +10 V terminal on the synthesizer board to +5 V also.
Apply power. The display should be cleared after operating the MODE button. If this does not happen, press the reset key. Verify that $\overline{\text{RESET}}$ of the microprocessor is logic high. Now type a few numbers on the keyboard, and check that these are displayed correctly. Read up the section on the use of the command keys (Part 1), and check that the



Side view of the completed static LC display board, showing that the controller chips and the glass LC display are mounted at opposite sides of the board.

special mode indication symbols appear on the display (decimal points, dash on the LED type and small square on the LC type). The OUT OF LOCK LED should light because the local oscillator (and prescaler) is yet missing from the phase-locked loop.
It can safely be assumed that the microprocessor board, keypad and display function correctly if the above test checks out.

In the receiver

Since the microprocessor-controlled radio synthesizer is a general-purpose design, users must rely on their own knowledge and experience when it comes to incorporating the prescaler and synthesizer modules in an existing receiver. A few general observations can be made, though:

1. Be sure to understand how the receiver is actually tuned. If it has mechanical tuning (inductor/variable capacitor), this must be replaced with a varicap system as shown in Fig. 1 in Part 1. For SW receivers, it is recommended to use a modern varicap with a relatively high C_{max}/C_{min} ratio, e.g. Toko's KV1235 or KV1236, to enable using a low control voltage (max. 10 V or 25 V respectively). If the local oscillator inductor provides a DC path to ground for the varicap, and C is not required for defining the tuning rate, then C and R can be omitted.
It is strongly recommended to *first* convert the receiver as shown, *then* use an external potentiometer to find out what range of the tuning voltage is required to ensure the receiver's original frequency coverage, and *only then* attempt to bias the varicap by the synthesizer's output loop filter.
If the receiver already has electronic tuning, i.e., if it is tuned by a single tuning voltage obtained from a potentiometer or a channel preset unit, simply measure the tuning voltage range, and connect the tuning voltage input to the output of the loop filter via a short length of screened cable. Dimension the supply to opamp IC_2 as explained above.
2. The local oscillator in the receiver must be 'tapped' to provide the input signal for the relevant prescaler. It is important to ensure that this signal is of sufficient amplitude, but every care should be taken to prevent the oscillator being significantly loaded. Most transistorized receivers have a buffer stage between the local oscillator and the mixer. The input of the prescaler is then conveniently connected to a low-impedance point at the buffer output by means of a short length of thin coaxial cable. Coupling out of the LO signal via a tank inductor in the oscillator is not recommended as it will degrade the quality (Q) factor — this may limit the tuning range, and reduce the oscillator output power to the mixer.
For some SW and MW applications, it is possible to omit the 40 MHz prescaler and drive the MC145157 direct with the oscillator signal. This can, however, only be done when the LO signal has a frequency lower than 15 MHz, and an amplitude of at least 500 mV. The author developed and debugged his prototype of the synthesizer using a simple LW/MW/SW radio based on the Type TDA1083 one-chip receiver IC. This operated satisfactorily with pin 5 AC-coupled direct to the MC145157 with no buffering.
For VHF FM applications, the prescaler used (Fig. 9) is sufficiently sensitive to enable driving it by relatively small amplitudes of the LO signal. For instance, in the case of the LP1186 tunerhead, the LO signal can be taken from the emitter of oscillator transistor BF195 (near the centre of the PCB).
It is strongly recommended to check that the prescaler used (whether the SW or VHF type, or both) functions correctly. Temporarily fit it in the receiver, near the local oscillator, and measure the output signal frequency (SW: ÷5 or ÷10; VHF: ÷10) to verify that it receives enough LO signal, and does not in any way affect the receiver's normal behaviour. Use a 15 MHz oscilloscope to check that the output signal is of digital amplitude (5 V_{pp}), and free from spurious pulses and noise, which could point to parasitic oscillation.

Before closing the loop...

Be sure that the following questions are answered in the affirmative before actually connecting the completed sythesizer to the receiver:

a. Does the receiver work as before with varicap tuning installed, and can it be tuned by a temporarily fitted potentiometer?
b. Is the supply voltage for the active loop filter (IC_2) in accordance with the maximum required tuning voltage, and are the prescaler and synthesizer boards correctly powered?
c. Does the prescaler supply a correct output signal at all settings of the receiver tuning?
d. Is the band/I.F. setting for the micro-

processor board in accordance with the actual intermediate frequency of the receiver? (consult Table 1 and the technical specification of the receiver).

As a final check, leave the output of the loop filter disconnected from the LO tuning input, and program a frequency within the receiver's tuning range. Connect a voltmeter or a DC-coupled oscilloscope to the loop filter output. As the external potentiometer is operated to tune the radio through this frequency, the filter output should switch from one extreme to another. Until all of the above tests pass, it is not useful to close the loop, as it is then very hard to distinguish the cause of a problem from its effects.

The microprocessor board, keypad, display, and 5 V power supply are housed in a desk-style ABS enclosure. The band/I.F. selection switches are fitted as a 4-way DIP switch block on the sloping front panel.

The connection to the synthesizer board in the receiver is made in a 6-wire cable terminated in a 9-pin D-connector plugged into a mating socket at the rear of the enclosure. The signals carried in this cable are:

- LE, DATA and CLK (from microprocessor to IC_1);
- S/R (from IC_1 to the LED display board);
- $\overline{\text{RESET}}$ (from T_1 to the microprocessor);
- ground.

It should be noted that S/R is not required when the static display board is used.

The quartz crystal on the microprocessor board may be replaced with a 1.8432 MHz or 2 MHz type, which is generally less expensive than a 1 MHz type.

The only problems that could be experienced with the synthesizer are instability of the LO frequency and audible reference frequency on the output of the radio. Either of these problems should be resolved by empirically adjusting R_7 through R_{10}. R_9 and R_{10} should normally be in the range from 1 kΩ to 10 kΩ, and R_7 and R_8 in the range from 10 kΩ to 50 kΩ. Accurate values can not be predicted as these depend on factors which vary between oscillators. The most significant of these is the tuning rate expressed in MHz per volt. The values shown in Fig. 3 were used with a dual-conversion shortwave receiver with a tuning rate of about 1 MHz/volt.

If, after adjusting the above resistors, the reference frequency can still be heard, the tuning rate may need to be reduced by using a smaller valued C (Fig. 1), and adding a fixed capacitor across the oscillator inductor. This will increase the Q of the oscillator and reduce phase noise. If the tuning range becomes too small, it can be restored by switching oscillator inductors.

Finally, the prescaler and synthesizer boards installed in the receiver should be fitted in screened metal enclosures.

Reference:

[1] Microprocessor-controlled radio synthesizer — 1. *Elektor Electronics* July/August 1988, p. 18-24.

GEN. INTEREST NEWS

First IEE/NCC Software Engineering Graduates

During the summer, the first students to train for the new IEE/NCC Certificate in Software Engineering have successfully completed their course and graduated from the Defence ADP Training Centre at Blandford, Dorset (a private training organization).

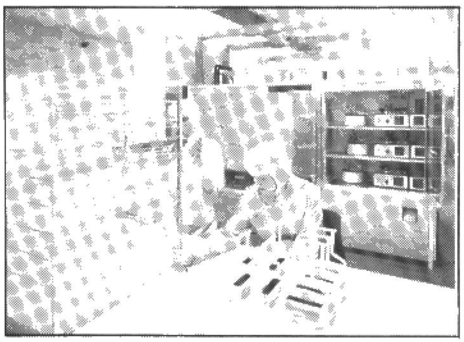
Since its launch in 1987, the certificate course has generated widespread interest throughout industry and academia. Over 230 colleges and private sector training organizations have expressed interest in running the course and 47 have submitted applications to do so.

For further information, contact The SCEB Secretariat • Qualifications Department • IEE • Savoy Place • LONDON WC2R 0BL • Telephone 01-240 1871 Ext 313 or 239.

New process for attaching SMDs

A new process for attaching surface-mount devices to ceramic circuit boards, developed and patented by British Aerospace, provides improved heat transfer, elimination of residual contamination, and better access for inspection, resulting in improved quality and operational life.

Details from Microelectronics Technology Centre • British Aerospace • Manor Road • HATFIELD AL10 9LL • Telephone +44 438 312422.



A new semiconductor manufacturing plant, believed to be one of the most advanced of its kind in Europe, has been opened by Hawker Siddeley subsidiary Westcode Semiconductors at Chippenham.

Electrical fault-detection and alarm system

An alarm system designed to detect electrical faults and eliminate the need to install miles of multi-core cable on large installations has been developed by Mardek Control Systems.

The system is suitable for such applications as monitoring the situation at the stern of a ship or pinpointing faults in road or railway tunnels. It is immune to electrical noise and also allows such equipment as motors and fans to be operated by remote control.

The equipment can handle 16 individual inputs at up to 240 VAC and incorporates a cable-check circuit.

Further information from Mardek Control Systems • Lynwood Business Centre • Lynwood Terrace • NEWCASTLE-ON-TYNE NE4 6UL.

Inexpensive testing of PCBs

Low-cost automatic test equipment for unpopulated PCBs, including surface-mount and hybrid types, is available from MP Systems. Typecoded 'MPS 3000', the equipment has a 'bed of nails' fixture with up to 3,072 pins that can accommodate boards measuring up to 300×400 mm. Close-centre probes with a spacing of 1.27 mm are available for testing surface-mount boards; double-sided probing is available.

The 40-character two-colour printer provides hard-copy output of the fault analysis. Test results are displayed on the VDU screen and no specialist training is required.

The system is claimed to cost only a quarter of the price of conventional grid-based machines.

Details from MP Systems Ltd • 37a Canterbury Road • WORTHING BN13 1AW • FAX +44 903 830037.

SHIELDING COMPUTERS WITH METAL-COATED GLASS

by Bill Pressdee, BSc, CEng, MIEE

Shielding for electromagnetic and radio-frequency interference (EMI/RFI) has two distinct functions. In the first instance, its purpose is to keep unwanted electromagnetic fields and unwanted transmission from interfering with sensitive electronic equipment. A second reason that has come about in recent years is keeping transmissions inside a given system.

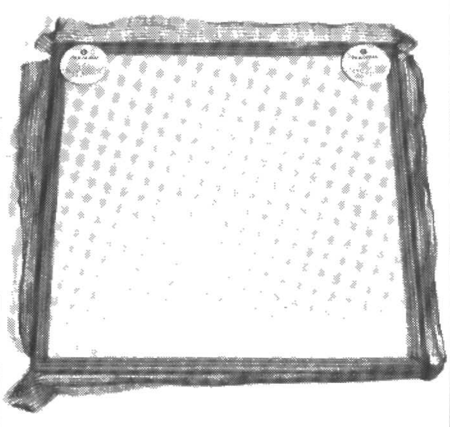
For many years a shielded room, or Faraday cage, has been a prerequisite for exact setting up of electronic circuitry in conditions free from extraneous interference. Early shielded rooms, totally enclosed by an earthed metallic mesh frame were, however, often expensive to construct and claustrophobic.

The puncturing of the screen to introduce ventilation often created additional problems with the result that air flow was minimal. As a result of these indifferent working conditions much of the purpose of the Faraday cage was frequently confounded by personnel leaving the shielded door open.

In recent years, with an emergence in the diplomatic and military fields of extremely sophisticated eavesdropping equipment, a second reason for shielding has come into prominence. As much emphasis is now placed on keeping transmissions in as keeping them out. This is equally true in the commercial field where radiation from computer circuitry can easily be detected by relatively simple equipment and valuable data siphoned off by those involved in commercial espionage.

In the United Kingdom and other countries where a Data Protection Act has been introduced it has, in any case, become a legal obligation for data to be adequately protected. A general tightening up of international standards relating to RF transmissions from electronic equipment in general, with stricter regulations governing this likely to become mandatory in Britain and most of Europe this year, has given a fillip to the shielded enclosure market.

In some cases where, for example, major computer installations are situated near airports or sites where there is the prospect of considerable interference from radar equipment, beacons, broadcast transmitters, mobile radios, and industrial or medical apparatus, there is a double problem. The shielding must ensure that unwanted transmissions do not corrupt data or hamper operation, and at the same time must secure the integrity of the computer data from eavesdropping.



The laminated glass has a peripheral wire mesh strongly bonded to the conducting coating.

Problems of shielding

Effective shielding of computer rooms and sensitive electronic equipment can be achieved by enclosing them in a metallic cage of wire mesh. In the case of equipment, windows in the cage need to be provided to enable dials or displays to be read. In the case of computer rooms, particularly those manned on a round-the-clock basis, total enclosure is claustrophobic and oppressive in the absence of daylight.

Even where windows are provided, they have to be covered with wire mesh to ensure the shielding is complete and this may well add to the feeling of imprisonment.

An expensive alternative in the past where windows have had to be shielded against RFI was in the use of conductively coated glass. The preferred materials for coating were gold and indium tin oxide (ITO). The window size, however, has been restricted by the dimensions of the vacuum chambers available for deposition. In addition, in the case of ITO the cost of large pieces has been prohibitive because the deposition rate is slow, which means tying up expensive plant for long periods.

The problems of manufacturing large pieces of metallic coated glass at reasonable cost have been solved by Pilkington Glass, one of the world's foremost glass manufacturers. The process involves the use of very-large-scale magnetron sputtering equipment, capable of producing conductively coated glass in sizes up to 3.6 m × 2.5 m.

The plant operates on a continuous basis with vacuum locks on the main sputtering chamber enabling a very high manufacturing throughput. Many different materials can be deposited by this process, but for RFI shielding windows, materials possessing high electrical conductivity combined with good optical properties in thin film form are chosen.

The result of this is a material that can be used in the manufacture of windows with an attractive appearance and little visual obscuration. While the shielding properties may not satisfy the most stringent specifications it is quite satisfactory for a wide range of applications such as windows for data sensitive areas like computer rooms, RFI shielding cabinet doors and video display unit (VDU) faceplates. The laminate protects the operator's upper body from bombardment by radiation, a suspected cause of headaches and other ills.

The coated glass is laminated to a second piece of glass to protect coating and a peripheral metallic mesh tape completes the shielding connection.

Types of coated glass

Several types of coated glass are available, depending on the thickness of conducting layer which will determine the degree of shielding from electromagnetic waves, and further types

with improved performance are under development. The thickness of the layer will determine the surface resistance which is in the range 2 to 20 ohms/square (where ohms/square is the unit for measurement of surface resistance). The densest coating (2 ohms/square) naturally has the lowest optical transmission, which is of the order of 50 %.

Apart from the standard laminated sheet, an interesting case arises where a laminate is formed from two metallized glasses separated by a non-absorbing interlayer less than 1 mm thick. Radiation that penetrates the first surface becomes trapped between the two surfaces, which act as mirrors, and only escapes after multiple reflections due to the high reflectivity.

Since the reflections are as likely to escape through either glass, roughly only half of the energy managing to penetrate the coating will be transmitted on into the shielded area. In practice, improvements in attenuation of 8 to 10 dB over the single coat laminate have been recorded.

From an architectural viewpoint an important additional consideration in selection of a glass type — provided the screening requirements are met — is the ratio of light to solar heat transmission. In the case of the 2 ohms/square coating, the relative percentages for reduction are 50/30, so by its employment there is considerable offspin.

In summer, the solar heat gain of the building through the windows is greatly reduced (to about one-third), while in the winter, the same applies to heat losses from the building via the windows, providing for lower fuel bills.

Window construction

The conductive coatings may also be protected from abrasion by incorporation in a double-glazed unit. For internal applications the preferred construction is laminated, since it is less bulky and gives a much increased strength. The knitted wire mesh around the perimeter of the sheet is brought into good electrical contact with the coating by the pressure of the lamination process.

Double-glazed units are more suited to external or architectural use since this construction gives the additional benefit of lower heat loss. The conductive connection around the perimeter of the window unit may be of the wire mesh type or by depositing a robust metal coating. Where there is a need to provide RF shielding for an existing room with normal windows, secondary glazing is a possibility. The additional windows would be of laminated construction, mounted in a metal framework grounded to the rest of the structure, and constitute the least expensive option for a retro-fit.

A number of different coatings are under investigation. Where a coating durable enough to be used without protection is essential, one employing ITO can be offered, but cheaper coatings with similar properties are being developed. Also, a coating similar to the ones at present in use, but able to withstand the high temperatures involved in toughening and bending the glass for special applications, is under development.

Pilkington Glass Ltd, New Technology Business Unit, Cowley Hill Works, ST HELENS, WA10 3TT.

GEN. INTEREST NEWS

UK payload equipment for new French satellites

Britain's Marconi group is to design, develop and manufacture communications payload equipment for the French Telecom 2/Syracuse 2 joint civil/military satellites which are due to be launched from 1991 onwards. The equipment includes command, telemetry and ranging systems, and consists of advanced transmitters and receivers operating at 7 and 8 GHz.

The contract, placed with Marconi Space Systems by Alcatel Espace of France, is for the supply of three sets of flight standard hardware together with development and engineering models. The existence of an in-house technology programme, aimed at meeting local oscillator and carrier generator requirements with advanced frequency generation designs, was a key factor in the award.

Marconi has considerable experience in the design and manufacture of 7/8 GHz equipment, most recently in its role as payload prime contractor for the British armed forces Skynet 4 and the NATO IV communications satellite programmes. The techniques developed at these frequencies have also been successfully extended by Marconi Space Systems to provide a broad capability in space communication links up to 45 GHz.

Earlier, Marconi was the first European company to build an operational communications satellite, the UK Ministry of Defence's Skynet 2, and the associated ground network of central communications earth stations and a range of fixed and transportable earth terminals.

Marconi Space Systems has accumulated nearly 23 years experience in spacecraft design and manufacture for communications, remote sensing and scientific application satellites. The company has been involved as prime and major contractor in some 50 national and international satellite projects.

(Marconi Space Systems Limited, Anchorage Road, PORTSMOUTH, PO3 5PU; Telephone +44-705 664966; Telex 86666; Fax +44-705 690 455)

Military markets for C^3I in Europe

An analysis from Frost & Sullivan says that European countries will be spending more than $ 22 billion over the next few years on C^3I – (command, control, communication, and intelligence). Much of this equipment is commercial in origin and is seen as a 'force multiplier', enabling faster and more informed military decision-making in the face of numerically superior Warsaw-pact forces.

The report, *Military C^3I in Europe (#E1002)*, shows Hughes to be the largest supplier, followed by Thomson-CSF and GEC-Marconi.

Frost & Sullivan • Sullivan House • 4 Grosvenor Gardens • LONDON SW1W 0DH • Telex 261671 • FAX +44 1730 3343.

First private transatlantic optical fibre cable

The UK end of the PTAT1 transatlantic cable was brought ashore at Brean during the early summer. It is the first privately funded fibre optic cable linking North America and Europe.

PTAT 1 will be operated in the UK by Mercury, the wholly owned subsidiary of the Cable and Wireless company. It will link into Mercury's national optical fibre network and will also provide onward international connections to Europe via Mercury's optical fibre cables to France and The Netherlands. PTAT forms a vital link in the Cable and Wireless Group's strategy for a Global Digital Highway.

PTAT 1, which will come ashore in the US at Manasquan in New Jersey, is a four fibre pair configuration with three fibres operating at 420 Mbit/s. The fourth pair is spare. Submarine branching units will route one fibre pair via Bermuda and Ireland and will provide services between Bermuda, the UK, Ireland and the US.

The new link is expected to be ready for service in mid 1989. A second cable, PTAT 2, is expected to come into operation in 1992, unless demand necessitates an earlier completion.

(Mercury Communications Ltd, 90 Long Acre, LONDON WC2E 9NP; Telephone +44 1 528 2000; Telex 910000 MERCOM G; FAX 528 2181)

THE BRITISH LIBRARY

by Ann Abbott

The British Library's Document Supply Centre (BLDSC) at Boston Spa in West Yorkshire houses the largest collection of readily accessible material in the world. It was set up primarily to meet the needs of Britain's scientists and researchers for global information. At the same time it can supply almost any document, article or report to academic or commercial researchers overseas.
In fact, overseas customers — 7000 from 144 countries — now outnumber United Kingdom registered users, and overall demand from abroad is increasing by around 5% a year. The centre handles in all one enquiry every two seconds, lending or supplying photocopies or microfiche duplicates from a stock of 7 million books, journals, reports and theses.
The journals listing alone contains over 10,000 titles on chemistry and chemical engineering, 8,000 on biomedical research, 30,000 on other biosciences and over 40,000 on engineering. As a depository for all European Community documents, the BLDSC's speed of supply and comprehensive coverage is particularly important.

Satellite delivery

The information is so readily available because the centre uses latest information technology, with direct links to several databases plus facilities to accept and meet requests electronically. It has new generation facsimile machines and laser printers and is experimenting with satellite links while pioneering compact discs for storage and retrieval.
The centre is keen to use the joint European Space Agency and Commission of European Communities' APOLLO satellite for the delivery of facsimile documents to western Europe, and has already held one pre-APOLLO trial. In 1987, digitized pages were transmitted 40,000 kilometres to the EUTELSAT ECS-F2 satellite over west Africa, bounced back to Boston Spa, and printed out.
Closer to home, the BLDSC is using its own digital circuit to send transmissions on a Group IV facsimile machine to London, where they continue via public digital circuits to the capital's University College. Group IV's are 12 times faster than previous generation machines, offer better transmission quality, and are intended for the Integrated Digital Services Network, the global conversion from analogue circuits which will offer advanced new communications facilities from 1990.
When the international digital network becomes fully operational, the library's customers will be able to search its memory remotely for articles and output them on its own laser printers.

Cheap and efficient

But accessing information is even now almost as simple. Requests are accepted by mail, telex, and the automated document-request service of such major database hosts as DIALOG, SDC, BLAISE, ESA and the OCLC Interlibrary Loan Subsystem.
A listings service allows customers to make their own search via a database and request several items to be dealt with at the same time and by a nominated person. Demand for this service from overseas users has recently increased by 25%.
Said director David Russon: 'As we mostly send photocopies it does not deplete our resources and our prices are reasonable as we have paid a lot of attention to efficiency. We had clear objectives from the start to make information available readily and cheaply.'
Postal requests are made on the centre's own forms – provided free of charge – and prepaid by an attached coupon. The coupons, each valid for ten pages of photocopy from the original, are available either form the library or its representatives in most countries where the British Council has a presence.
The British Council represents the British Library in its cultural role - promoting learning and sharing the benefits of knowledge. It will usually accept the local currency.
Deposit accounts are also available to overseas customers, as are surrogate forms for use on facsimile or telex. Over 90% of requests are met, and no charge is made for fruitless searches. Turnaround is generally within two days, but a fast, same day service is available at slightly higher cost. Of the requests met, virtually all are from stock with back-up provided by university libraries, including those at Oxford and Cambridge.
With its computerized records the library is skilled at meeting quite vague requests. All the help one customer could give were the words 'Eric' and 'cause'. The date, venue and authorship were not known. It took the centre two minutes to find the paper, which was given in Missouri, in the United States, in 1981.

War records

It is notoriously difficult to identify published conference proceedings as they can be referred to in different ways. The

The British Library Document Supply Centre computer facility.

indexes published by the Document Supply Centre are a valuable aid to identification since they permit access by keywords in the titles of conferences.
The Conference Index is now the largest bibliography of its kind in the world, with over 220,000 conferences in all subjects and languages. The centre also holds some papers which were prepared but never given, and even certain papers published in Japan on only a local level. Much of the Japanese material is available with at least part translated into English.
The German War Records, which detail low technology solutions using indigenous materials, NASA reports and the design studies of Chernobyl, are among recently sought items. Developing countries are interested in Germany's innovations during World War II, while space medicine, with its studies of weightlessness and bone loss, is becoming of wider interest.
The library's Medical Information Service — responsible for British and European input into the American National Library of Medicine's database, Medline — also generates original listings covering complementary (or alternative) medicine, physiotherapy, occupational therapy and sports medicine.
A publisher in its own right, the BLDSC translates a number of foreign journals cover to cover, and republishes them in full. The 12 current titles cover chemistry, physics and mathematics.

DATA PROTECTION ACT: KEEPING THE RECORDS STRAIGHT

by Nigel Waters

The all-pervasive use of computers has brought with it a growing concern that the exchange of information they make possible, and the sheer volume of data they can process, could present problems. Errors, omissions and the misuse of data could all damage someone's reputation, creditworthiness, job prospects or educational opportunities, to give just a few examples.
With this in mind the Council of Europe produced the Convention for the Protection of Individuals with regard to Automatic Processing of Personal Data. A number of countries have already ratified the convention.
In the United Kingdom, the Data Protection Act received the Royal Assent and passed on to the statute book in 1984. The various provisions of the Act were then introduced in stages, with the final elements implemented in November 1987.
Britain's Data Protection Act meets two concerns. First, the threat that misuse of computers might pose to individuals and, second, the possibility of damage to United Kingdom trade if countries ratifying the convention restricted the transfer of personal data to countries with equivalent safeguards.
The Act gives new rights to individuals. They can see information held on computer about themselves and, where appropriate, have records corrected or erased. Where damage has been caused, they can claim compensation. They can also turn for help to a national ombudsman — the Data Protection Registrar, Eric Howe.

Nigel Waters is Assistant Data Protection Registrar at the Office of the Data Protection Registrar, Wilmslow, Cheshire.

Official guidelines

Data users who control the information being processed on their own or someone else's computer and computer bureaux are required to register with the data protection registrar.
Data users are also required to observe eight data protection principles. Broadly speaking, these require that users handling personal data must:

* Obtain and process the information fairly and lawfully.
* Register the purposes for which they hold it.
* Not use or disclose the information in a way contrary to those purposes.
* Hold only information that is adequate, relevant and not excessive for the purposes.
* Hold only accurate information and where necessary, keep it up to date.

The United Kingdom Data Protection Act prevents the misuse of personal records held on computer.

* Not keep the information any longer than necessary.
* Give individuals access to information about themselves and where appropriate, correct or erase it.
* Take appropriate security measures (this principle also applies to computer bureaux).

If someone suspects that any computer user has broken a principle he or she can complain to the registrar who can investigate.

The Act creates the office of the data protection registrar, who is independent and ultimately responsible to Parliament. His duties are to:

* Establish and maintain the register of data users and computer bureaux and make this publicly available.
* Disseminate information on the Act and its operation.
* Promote the observance of the data protection principles.
* Encourage, where appropriate, the development of codes of practice to assist data users in complying with the principles.
* Consider complaints about contravention of the principles or other provisions of the Act.

Penalties for infringements

He may issue notices to enforce compliance with the principles, and may ultimately remove an entry from the register, making it an offence for a user to continue automatic processing of the data concerned. He may also prosecute for non-compliance with notices issued, or for other offences such as non-registration or unauthorised disclosure.

Data users and computer bureaux may appeal against the registrar's decisions to an independent data protection tribunal established under the Act. Offences can lead to fines of up to £2000 in the lower courts and unlimited figures in the higher courts.

A number of exemptions from all or parts of the Act allow for national security, personal, family or household affairs and for recreational purposes.

Conditional exemptions from the whole of the Act are available for certain uses such as where the data is held only for payroll and accounts.

There are some exemptions to people being able to see their own files – the subject access provisions of the Act – for instance, in cases where to do so would prejudice the prevention or detection of crime, the apprehension or prosecution of offenders, or the assessment or collection of a tax or duty.

Complaints being made

Health professionals may also withhold the personal data about a patient where they believe that to disclose it would seriously harm the person. There are similar provisions for social workers and their clients.

Nevertheless, individuals can appeal to the registrar where they believe that information is being wrongly withheld.

By the end of January 1988 the registrar had received 379 complaints from the public. The publicity about the final elements of the Act coming into operation from last November has increased the volume of complaints from 30 a month to 30 a week. Problems over subject access and unsolicited mail are two of the principal causes for complaint. Others are inaccuracy of data, misuse or wrongful disclosure, unfair collection and lack of security.

There have already been some successful prosecutions under the Act for non-registration and, for example, for unauthorised access to police files.

Some criticisms

Smaller users tend to be put off by the very comprehensive registration forms. To help them, the registrar produced a shorter form that covered the four most common uses by small companies.

Another criticism is that the Government set too high the maximum fee that can be charged for producing a copy of an individual's file. It is £10 for each request and where there is a registered multiple use, he can be charged for access to each separate file. Data users may, of course, charge less than £10 or nothing at all. Indeed some organisations, including a number of local authorities, in certain circumstances make no charge, or charge a very low fee for subject access.

NEW COURSES FOR RADIO AND TELEVISION AMATEURS

North Trafford College are offering another Radio Amateurs' Course starting this month. The City & Guilds of London Institute Course 765 leads to the Radio Amateurs' Examination for licence 'A' or 'B'. The 'A' Licence enables the Radio Amateur to operate on 'all bands', which include short waves, VHF, and UHF, while the 'B' Licence enables the amateur to operate on VHF (30 MHz and above).

The Full Day Course should appeal to the unemployed, as a successful student could apply for an 'A' Licence at the end of the first year. It should be noted that unemployed students can attend the College for a maximum of 21 hours each week and also receive FULL unemployment benefit.

The College is fully equipped with a complete working amateur radio station: call sign G4FXP.

For people already in possession of a class 'A' or 'B' Amateur Radio Licence, a new course, Amateur Television Theory and Construction is planned to commence this month. The course includes television engineering theory, the Video Camera, and practical activities. Enrolment dates are 7, 8, and 9 September.

Details from J.T. Beaumont • North Trafford College of Further Education • Talbot Road • Stretford • MANCHESTER M32 0XH • Telephone 061 872 3731 Ext. 45.

CORRECTIONS

Multi-function frequency meter

December 1987, p. 46-49.

The PRIME circuit, which is used for measuring large time intervals, has been connected thew wrong way around.

* Pin 6 of IC_2 should be connected to pin 9 of IC_1, not pin 5.
* Pin 2 of IC_2 should be connected to pin 5 of IC_1, not pin 9.

The relevant connections between IC_1 and R_{12} on the PCB are readily swapped — the two tracks immediately next to IC_1 are cut and then connected crossways.

Ga-As FET converter for 23 cm ATV

July/August 1988, p. 45-49

Voltage regulator IC_1 is shown with the wrong orientation on the component overlay in Fig. 2. The flat side of the device should face C18, not the side panel of the enclosure.

MICROCONTROLLER-DRIVEN POWER SUPPLY — 3

Although the intelligent power supply can operate in stand-alone mode without an external computer, its true power and versatility can not be appreciated until use is made of the serial interface that enables a number of instruments to be connected to a simple, yet flexible, control bus.
As promised two months ago, this third and final instalment of the article will focus mainly on the supply's ability to respond to software control. It will be shown that this is relatively simple to effect, since the bus hardware and command data format have been designed with flexibility in mind, allowing almost any computer to be used, provided it has a programmable serial port. At the end of the article, a number of BASIC example routines are given to aid in getting acquainted with our first computer-controlled test instrument.

Nothwithstanding what has been said above, and to get things straight from the outset: the microcontroller-driven power supply as described in Parts 1 and 2 of this article can be used **autonomously**, i.e., the software control described here is an **add-on option**.
Just to illustrate the benefits that software control can bring to a power supply, Fig. 19 shows an Amstrad PC-XT compatible computer displaying the voltage—current response of a negative temperature co-efficient (NTC) resistor, connected to the output of the intelligent power supply. Via its RS232 channel, the computer is able to control the supply, and read measured voltage and current for processing and displaying in the form of a curve on the monitor.
With reference to Fig. 2 in Part 1 of this article, optocouplers IC_6 and IC_7 in the basic serial interface ensure complete galvanic insulation of the power supply and the control computer. Received serial signals (RxD) are converted to digital levels, and are applied to Port line P3.0 of the microcontroller. This, in turn, transmits status information via P3.1 to provide data to the computer (TxD). The optocouplers form part of a current-loop configuration.

A simple RS232 control bus

Two small add-on circuits, described below, enable a central host computer to control multiple test and measuring instruments via a single serial RS232 channel, which is thereby turned into an RS232 control bus. The choice between the two adaptors is governed mainly by the application in question, and user requirements.
The first circuit that can be used is shown in Fig. 20. It is essentially an RS232-to-current-loop converter with 3

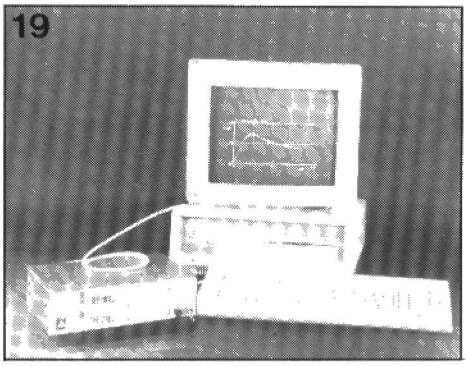

19

Fig. 19. The power supply under the control of an Amstrad PC-XT computer.

outputs. The circuit does not form part of the power supply, but is fitted in the hood of a 25-way D-connector, K_1, which is connected to the computer's RS232 outlet. Handshaking lines CTS and RTS are connected on the adaptor board. RTS supplies the positive supply voltage, +10 V, for the RxD line. Similarly, output TxD of the host computer supplies −10 V for the RxD line. This arrangements does away with the need for a separate symmetrical supply for the RS232 interface (remember that it is not possible to use the ±12 V lines available in the PSU, if this is to remain galavanically insulated from the control bus, the instruments connected to it, and the host computer).
FET T_1 is a constant-current source that supplies about 5 mA to the LEDs in the optocouplers that form part of the instruments connected to the bus. Note that the LEDs are connected in series, requiring pins 4 and 5 of non-used D9-connectors to be interconnected to prevent breaking the current loop. R_3 is the common emitter-resistor for the transistors in the optocouplers. The circuit of Fig. 20 allows up to 6 instruments to be connected to the bus, provided the host computer supplies ±12 V at its RS232 outlet. Some computers supply only ±5 V, which limits the number of instruments that can be connected to 2 or 3.
The circuit of Fig. 20 is built largely in surface-mount technology on the miniature PCB shown in Fig. 21. This board is mounted direct on to one of the 13-pin rows of a D-25 connector as shown in the photograph. Pins 9 up to and including 13 are cut off as close as possible to the connector body. Pin 8 is also cut off, but left long enough to enable it to be connected to pins 6 and 20 later. C_1 and C_2 are miniature electrolytic capacitors, so that the connector hood can be closed with the completed circuit board inside. After mounting the components, solder the relevant copper islands direct to pins 2, 3, 4, 5 and 7 of K_1.
The previously described circuit is particularly useful when relatively few instruments are connected. The second add-on interface circuit described can, in principle, control an unlimited number of instruments, provided the (now separate) power supply can handle the current requirement of about 5 mA per instrument.
The circuit diagram of Fig. 22 is even simpler than that of Fig. 20, and shows that 'bused' instruments are effectively driven in parallel. A separate power supply — **not** that in the microcontroller-driven PSU — provides the required symmetrical voltages. In most cases, it will be possible to 'tap' the computer's built-in power supply, and connect this to two unused pins on the D-25 RS232 connector. Alternatively, to prevent compatibility problems, fit the interface with two separate supply connections, so that it can be fed from an external ±12 V supply. Components R_1, R_2 and T_1 are conveniently housed in

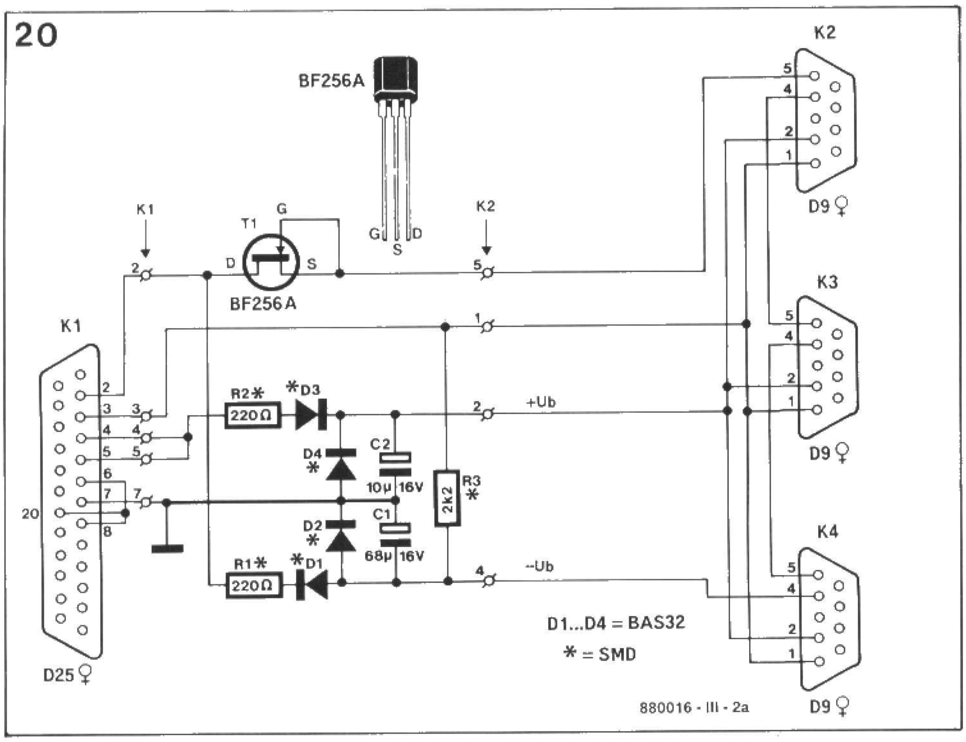


Fig. 20. This adaptor circuit makes it possible to connect up to six power supplies to the host computer. The circuit is fed from RS232 lines, and is small enough to be fitted inside the hood of a D25-connector.

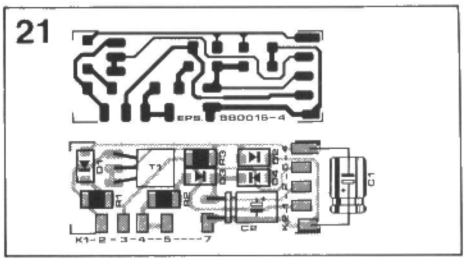


Fig. 21. True-size track layout and component overlay of the adaptor (circuit diagram: Fig. 19). The passive components and diodes are surface-mount assembly (SMA) types. Note that the component overlay is not actually printed on the ready-made board.

Parts list
ADAPTOR BOARD, CIRCUIT DIAGRAM: FIG. 20

Resistors (SMA types):
R1;R2 = 220R
R3 = 2K2

Capacitors:
C1 = 68µ; 16 V; miniature axial.
C2 = 10µ; 16 V; miniature radial.

Semiconductors:
D1;D2;D3 = BAS32 (= SMA version of 1N4148)
T1 = BF256A

Miscellaneous:
K1 = 25-way female sub-D connector with screwdown hood.
K2 = 9-way male sub-D connector with screwdown hood.
PCB Type 880016-4 (included in PCB set for this project — see Readers Services page).

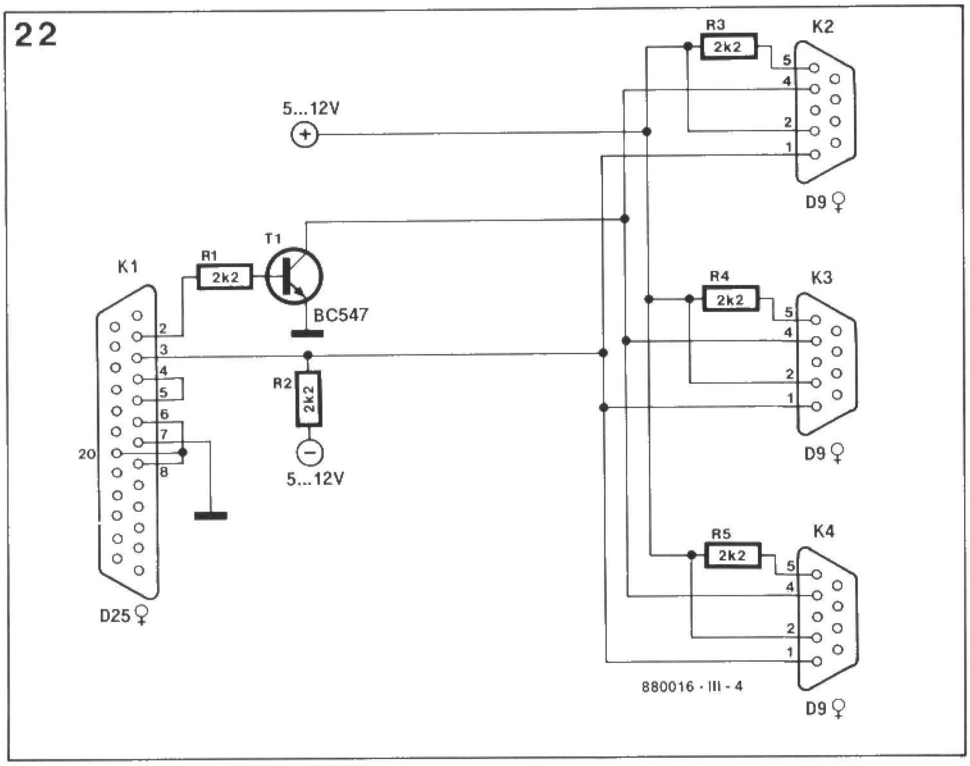


Fig. 22. This adaptor circuit is fed from an external supply, and can, in principle, drive an unlimited number of bus-connected instruments.

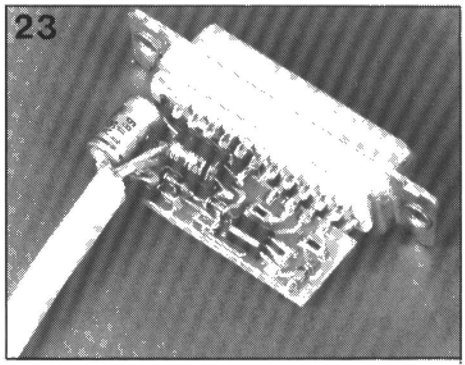


Fig. 23. Prototype of the adaptor circuit; it is built mainly in surface-mount technology.

the connector hood, while each 9-pin D-connector takes a series-resistor for the LED in the opto-coupler. Do not forget to make connections 4—5, and 6—8—20 in the 25-way D-connector.

Inside the power supply

A few minor modifications are required in the microcontroller-driven PSU to enable it to work with either one of the previously described interfaces.

For the following description it is recommended to refer to the following drawings: Fig. 2 (Part 1), Fig. 10 (Part 2), and Fig. 24 (given here).

To prevent the RS232 signal being inverted, transistor T_7 should be replaced with a pnp Type BC557, or a FET Type BS250. The actual replacement on the PCB is simple to effect as shown in Fig. 24. Note that both the BS250 and BC557 are fitted 'the wrong way around' with respect to the component overlay, which is correct for the BC547. No modifications are required to the PCB itself.

A few users of the supply have found it relatively slow to respond to changes in the output voltage setting. This problem can be resolved by fitting a 560 nF or 680 nF capacitor in position C_7 (Ref. Fig. 2). Note that an oscilloscope connected to the output of the PSU may show an exponential curve when the voltage is switched down. This effect, which dissapears when the supply is loaded, is due to the charge- or discharge

24

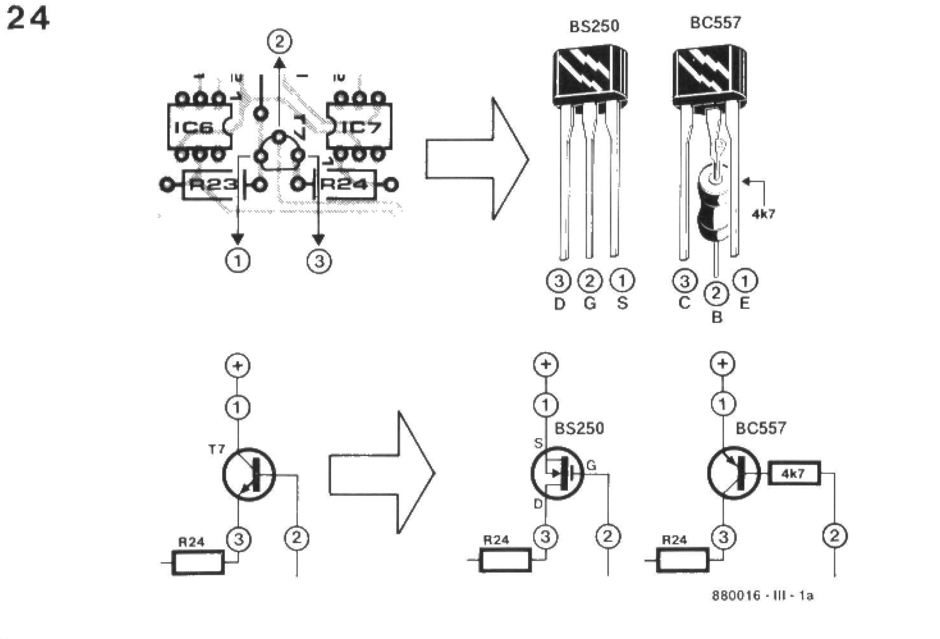


Fig. 24. Modifications on (not *to*) the PCB of Fig. 10 to enable the serial interface to work with the proposed bus structure.

Table 1.

D14	D13	D12	addresses
—	—	—	128 & 129
—	—	x	130 & 131
—	x	—	132 & 133
—	x	x	134 & 135
x	—	—	136 & 137
x	—	x	138 & 139
x	x	—	140 & 141
x	x	x	142 & 143

— = diode fitted
x = no diode

D_{15} is fitted or omitted in accordance with transformer used (see part 2).

D_{15} fitted:
I_{max} = 2.0 A
D_{15} not fitted:
I_{max} = 2.5 A

behaviour of the 220 μF smoothing capacitor on the output terminals. Any tendency of the supply to oscillate can be obviated by removing D_8 from the regulation board (Ref. Figs. 2 & 10).

The slight non-linearity just below 30 V of the voltage measurement circuitry can be corrected by increasing the value of C_3 (digital control circuit) by about 10%, or reducing the value of R_1 by the same amount (−10%). Either one of these measures, which have no effect on the adjustment procedure given in Part 2, should prevent the voltage on C_3 approaching that of the negative supply.

As already mentioned in Part 1, D_{12} to D_{14} are configuration diodes that define the identification code, or address, of the power supply on the control bus. The hardware-defined identification number makes it possible for the host computer to address bus-connected instruments individually. Codes 128 to 256 have been reserved for this purpose, enabling the microcontroller to detect the difference between an ASCII character, representing a command, and an instrument selection address. LED REMOTE CONTROL lights to indicate that the serial interface of the relevant instrument (supply) has been selected. The display and controls on the supply continue to function normally, however, unless inhibited by command NO LOCAL.

Addresses 128 up to and including 143 are reserved for power supplies. Each supply uses an odd- and an even-numbered address, so that a maximum of 8 PSUs can be installed. The required configuration of the diodes can be deduced from Table 1.

Command descriptions

The host computer should be programmed or hard-wired to have its RS232 port transmit and receive at 9600 bits/s, 8 databits, 2 stop bits, no parity. An overview of the available commands and their simple syntax is given in Table 2 — this can be copied and made into a

Table 2.

COMMAND	COMMAND DESCRIPTION	SUPPLY RESPONSE
[128_{DEC}...142_{DEC}]	even-numbered address; switch instrument on-line (open device)	
[129_{DEC}...143_{DEC}]	odd-numbered address; switch instrument off-line (close device)	
[0]	request status byte (see Table 3)	[0...$1F_{HEX}$]
[1]	request address (even-numbered identification code of instrument)	[128_{DEC}...142_{DEC}]
[24_{DEC}]	cancels last command, when not closed off with <CR>	
A<CR>	slow slope	
B<CR>	fast slope	
C<CR>	activates 0 V OUT (output voltage is made nought)	
D<CR>	de-activates 0 V OUT	
L<CR>	local on; enable front panel controls	
N<CR>	local off; inhibit (lock) front panel controls	
R<CR>	reset; load defaults from memory 1, activate 0 V OUT, switch instrument off-line	
U12.34<CR>	programs set output voltage (e.g. 12.34 V)	
I01.23<CR>	programs set current limit (e.g. 1.23 A)	
X<CR>	echo on; supply returns (echoes) received characters	
Y<CR>	echo off	
u<CR>	reads set output voltage	12.34<CR>
i<CR>	reads set current limit	01.23<CR>
v<CR>	reads measured output voltage	12.34<CR>
j<CR>	reads measured output current	01.15<CR>

[number] : denotes numerical value of transmitted byte
<CR> : carriage return; ASCII character 13_{DEC} ($0D_{HEX}$)
U12.34<CR> : sequence of ASCII characters. The corresponding numerical values of the bytes are:
55_{HEX}, 31_{HEX}, 32_{HEX}, $2E_{HEX}$, 33_{HEX}, 34_{HEX}, $0D_{HEX}$

reference card for use at the host computer.

There exist three types of commands (also refer to Table 2):

- Upper-case letters U or I followed by the required value of voltage or current, respectively, in decimal (A and V), and a closing <CR>. Example: U30.00<CR> sets the selected supply to 30 V output.
- Lower-case letters followed by a closing <CR> prompt the supply to return the requested value in decimal including non-significant zeros. When the supply is set to operate in the ECHO ON mode, it sends received commands back to the computer, followed by the relevant data. Example: u<CR> will cause the supply to answer u<CR>30.00<CR> (echo enabled).
- A number of commands for the supply are simply single letters followed by a closing carriage return, for example N<CR> for the NO LOCAL function. These commands do not cause the supply to 'answer', but they are, of course, sent back with ECHO ON selected.

Odd- and even-numbered address:
The even-numbered address is used for selecting the power supply (on line; REMOTE CONTROL LED on), and the odd-numbered for deselecting it (off line; REMOTE CONTROL LED off). The instrument selection code is not returned to the host computer unless the supply had already been set to the echo mode (which is not the case after power-on). Further to the description of the HOLD function given in Part 2 of this article, it should be noted that when the supply is first selected with HOLD on the front panel pressed, it echoes its identification code byte to the computer, but returns subsequent commands or characters as a slash ('/'), without a closing <CR>, to indicate that the serial interface is overridden by manual control of the instrument. With ECHO OFF, but HOLD active, the supply simply returns nothing at all to the computer.

The serial interface in any one of the instruments connected to the bus can be disabled by sending the relevant odd-numbered address. Example: a supply configured for addresses 130-131 is switched on-line by code 130, and off-line by code 131. Closing carriage returns are not required. The off-line code is only returned to the computer when the supply is in the ECHO ON mode. Once de-selected, a serial interface can only be accessed again by means of the correct on-line code. A <CR> sent to the supply after the off-line code is not returned to the computer, even when ECHO has been enabled.

Table 3.

0	0	0	1	0	1	1	0
b7	b6	b5	b4	b3	b2	b1	b0

	"1"	"0"
b0	echo on	echo off
b1	hold off	hold on
b2	ready	not ready
b3	t°>55 °C	t°<55 °C
b4	local on	local off
b5, b6, b7 = "0"		

Shaded areas denote default settings.

Status byte
To prevent the computer sending inappropriate or improperly timed commands to the supply, this can be prompted to send a status byte of configuration shown in Table 3. The computer can call up the status byte by sending command NUL (control-@ or 00_H, not ASCII 0), which is never echoed.
The status byte is sent even when key hold has been pressed, since the HOLD/TRACK function can be read out as the logic level of bit b1. The host computer should always wait until bit b2 is high (ready) before sending a new V/I setting or command to the power supply. Commands received while b2 is low are simply ignored, with the exception of STATUS (NUL; 00_H) and IDENTIFY (SOH; 01_H).
The function of b3 should speak for itself. As already discussed, function 0 V OUT is activated when the heat-sink temperature exceeds 65 °C. The supply is then automatically shut down to allow the temperature to drop to an acceptable level. When bit b4 in the status byte is high, the supply accepts commands from the front panel controls **and** the serial interace. When b4 is low, the front panel controls are disabled (NO LOCAL function).

Status byte request: command NUL 00_H

Command NUL can be sent at any time. With SOH (see below), it differs from other commands in that is never echoed by the supply. Instead, NUL prompts the supply to immediately send the status byte.
Here is an example to illustrate the operation of command NUL to request the status information:
00_H *command received by the supply*
05_H *status byte returned by the supply.*
Referring to the previously discussed bit assignment in the status byte, this means that the supply is in the NO LOCAL mode;
has a normal operating temperature;
is ready to accept a command;
is in the TRACK mode;
echoes characters received from the host.

Note: in the ECHO ON mode, reception on the host of the echo of the CR used for closing off each command does not guarantee the actual execution of this command. When the command returned has been subject to normal echoing (i.e., characters are sent back in their true form, not as / or ?), the echo of the CR merely indicates that the command has been received correctly, and is executable. Whether or not the command has actually been executed can only be ascertained by calling up the status byte.

Identification request: command SOH 01_H

Similar to command NUL, SOH (01_H) has no CR echo, and does not actually program the power supply. The function of SOH is to prompt the supply to send its identification number (even-numbered address), so that the host computer that controls the serial bus is able to request bus-connected devices to identify themselves. The practical use of SOH is apparent from the programming examples to be discussed below.

Special messages sent by the supply

- ?

When the supply is in the ECHO ON mode, it replaces incorrect characters with a question mark, i.e., the original character is not echoed. The returning of a ? means that the command that contained the incorrect character has been cancelled. For example, when the supply (with ECHO ON) receives sequence U12.3A, it returns U12.3?, and does not execute command U12.3, because it is syntactically incorrect.
The supply does not accept any new command until it has received a CR or a

CANCEL command. In the latter case, it is not necessary to send a CR before continuing. Thus, the sequence
U12.3AU12.34<CR>
does effectively nothing at all, in spite of the apparently correct sequence U12.34<CR>; the host will see U12.3??????<CR> returned by the supply.
However, sequences
U12.3A<CR>U12.34<CR>
and
U12.3W<CANCEL>U12.34<CR>
both result in the execution of command U12.34.

■ /
When ECHO and HOLD are both ON, the supply echoes each character received, except CR, as an oblique (/) to indicate that it does not accept software commands, although its serial interface is active and functioning (see also command NUL described above).

General-character commands

■ **CR and CANCEL (ctrl-X; 18H)**
Each command, with or without parameters, should be closed off with a CR (carriage return; 0DH), **not a CR-LF** (carriage return followed by line feed 0AH), which will not be accepted by the supply. CANCEL can be sent at any time in the sequence, but before the closing CR, to effectively prevent an erroneous command being executed by the supply.

■ **R<CR>**
This command resets the supply. The result is the same as switching the instrument on and off. Note that the serial interface is then switched off-line, so that the last character received on the host computer is the echoed CR following R (provided, of course, ECHO is ON).

Commands with parameters

General note: although the decimal point in the syntax of the parameters is only processed as a delimiter by the microcontroller in the supply, it is essential, and facilitates programming the host computer because it makes the parameter syntax compatible with that of BASIC (in particular, instruction PRINT USING).

Host computer sets supply parameters: Unn.nn<CR>
Set output voltage in volts. Parameter *nn.nn* is a decimal value between 0 and 30.00. Note the use of apparently non-significant leading zeros in the following examples:
U<CR> = U00.00<CR> = 0 V
U.23<CR> = U00.23<CR> = 230 mV
U2.30<CR> = U02.30<CR> = 2.3 V
U23.48<CR> = 23.48 V
U23.00<CR> = 23 V
Also study the following example of a mistake:
A voltage of 23.4 V is required, and the following sequence is typed:
U23.4<CR> = U02.34<CR> = 2.34 V.
To obtain the correct value, type U23.40<CR>.

Inn.nn<CR>
Set output current limit in ampères. Parameter *nn.nn* is a decimal value between 0 and 2.50. Examples:

```
PL/M-51 COMPILER    TO int handler. Scan display and keys, start ADC, upd DACs

        P1 = 0000$0000B;                                    /* Blank display. */

        scan_count = scan_count + 1;
        IF scan count = 8 THEN scan_count = 0;

        DO CASE scan_count;

          DO;                                                     /* Case 0 */
            once_per_two = NOT once_per two;         /* Needed for bar-display. */

            IF HIGH(U_displ_BCD) < 10
            THEN P0 = segment_table(HIGH(U_displ_BCD)) AND dec_point;
            ELSE P0 = segment_table(SHR(HIGH(U_displ_BCD),4));

            P2_0 = led.hold;
            P2_1 = led.U_1_t;
            com1 = activ_high;
          END;                                                /* End case 0 */

          DO;                                                     /* Case 1 */
            IF HIGH(U_displ_BCD) < 10
            THEN P0 = segment_table(SHR(LOW(U_displ BCD),4));
            ELSE P0 = segment_table(HIGH(U_displ_BCD) AND 0FH) AND dec_point;

            P2_0 = led.zero_out;
            P2_1 = led.U_I_2;
            com2 = activ_high;
          END;                                                /* End case 1 */

          DO;                                                     /* Case 2 */
            IF HIGH(U_displ_BCD) < 10
            THEN P0 = segment_table(LOW(U_displ_BCD) AND 0FH);
            ELSE P0 = segment_table(SHR(LOW(U_displ_BCD),4));

            P2_0 = led.slow_change;
            P2_1 = led.U_I_3;
            com3 = activ_high;
          END;                                                /* End case 2 */

          DO;                                                     /* Case 3 */
            P0 = segment_table(HIGH(I_displ_BCD)) AND dec point;
            P2_0 = led.temperature;
            P2 1 = led change_I;
            com4 = activ_high;
          END;                                                /* End case 3 */

          DO;                                                     /* Case 4 */
            P0 = segment_table(SHR(LOW(I displ_BCD),4));
            P2_0 = led.U set;
            P2 1 = led.I_set;
            com5 = activ high;
          END;                                                /* End case 4 */

          DO;                                                     /* Case 5 */
            P0 = segment_table(LOW(I_displ_BCD) AND 00001111B);
            P2_0 = led high_scale;
            P2_1 = led.low_scale;
            com6 = activ_high;
          END;                                                /* End case 5 */

          DO;                                                     /* Case 6 */

            /* Measured value is displayed every display scan ( bar ), set value   */
            /* only once per two scans ( dot ). That's why bar is brighter.        */
            /* MSB of BCD value of U_set resp. U_meas is used to determine dot and */
            /* bar.                                                                */
            IF once_per_two
              THEN DO;                                       /* Determine U dot. */
                     IF led low_scale = activ_low
                     THEN led_nr = HIGH(U set BCD);
                     ELSE DO;
                            led_nr = 0;
                            DO WHILE (HIGH(U_set_BCD) >= U_scale table(led_nr));
                              led nr = led_nr + 1,
                            END;
                          END;
                                                      /* Display U dot and U-bar. */
                     ana_displ_U = dot_table(led_nr) AND ana displ_U;
                   END;
              ELSE DO;                                       /* Determine U bar. */
                     IF led low_scale = activ_low
                     THEN led_nr = HIGH(U_meas BCD);
                     ELSE DO;
                            led_nr = 0;
                            DO WHILE (HIGH(U_meas_BCD) >= U_scale_table(led nr));
                              led_nr = led nr + 1;
                            END;
                          END;
                                                             /* Display U-bar. */
                     ana_displ_U = bar table(led nr),
                   END;

            P0 = LOW(ana_displ_U);
            P2 = (P2 OR 00000011B) AND HIGH(ana_displ_U);
            com7 = activ_high;
          END;                                                 /* End case 6 *
```

Fig. 25. An extract of the PL/M source code used for compiling and loading into the microcontroller's on-board 4 Kbyte ROM. Shown here are some display control routines.

26

```
10 REM *********** TEST PROGRAM 'OVERVOLTAGE PULSES' ***********
20 CLS
30 :
40 REM close files that are open
50  CLOSE
60 :
70 REM open communication port 'COM1:' (9600Bd, no parity, 8 bits, 2 stop bits)
80 REM as file number 1
90  OPEN "com1:9600,n,8,2" AS 1
100 :
110 REM delay (min. 0.2s) to get correct interface voltage
120  FOR DELAY=0 TO 1000: NEXT
130 :
140 GOSUB 5000:                          REM initialize and close all devices
150 :
160 :
170 REM ************ MAIN PROGRAM ***************
180 :
190 ADDRESS=132: GOSUB 1000:               REM open device 'ADDRESS'
200 :
210 REM initial settings
220  U0=15:                               REM starting voltage
230  COMMAND$="N": GOSUB 4000:            REM disable front panel control
240  COMMAND$="I": VALUE=.5: GOSUB 4000:  REM I=0.5A
250  COMMAND$="U": VALUE=U0: GOSUB 4000:  REM U=U0
260  COMMAND$="A": GOSUB 4000:            REM set slow slope
270 :
280 REM start test cycle
290  FOR NUMBER=1 TO 5
300   CLS: PRINT "          ***** MEASUREMENT NUMBER: "; NUMBER; " *****":
310   PRINT: PRINT: PRINT: PRINT
320   COMMAND$="A": GOSUB 4000:            REM set slow slope
330   COMMAND$="D": GOSUB 4000:            REM no 0V-out
340   COMMAND$="B": GOSUB 4000:            REM set fast slope
350   FOR OVERVOLTAGE=.5 TO 2 STEP .5
360    TIME=TIMER: WHILE TIMER-TIME<1: WEND:   REM delay 1s
370    COMMAND$="U": VALUE=U0+OVERVOLTAGE: GOSUB 4000
380    TIME=TIMER: WHILE TIMER-TIME<1: WEND:   REM delay 1s
390    COMMAND$="v": GOSUB 4000: INPUT#1,V$:   REM read measured voltage
400    PRINT "Voltage : ",V$;" V          ";
410    COMMAND$="j": GOSUB 4000: INPUT#1,J$:   REM read measured current
420    PRINT "Current : ",J$;" A"
430    COMMAND$="U": VALUE=U0: GOSUB 4000
440   NEXT OVERVOLTAGE
450   TIME=TIMER: WHILE TIMER-TIME<1: WEND:   REM delay 1 s.
460   COMMAND$="C": GOSUB 4000:              REM 0V-out
470   TIME=TIMER: WHILE TIMER-TIME<1: WEND:   REM delay 1 s.
480  NEXT NUMBER
490 COMMAND$="L": GOSUB 4000:                REM enable front panel control
500 GOSUB 2000:                              REM close device 'ADDRESS'
510 END
520 :
530 :
```

Fig. 26. Sample BASIC program that causes the supply to generate a rectangular pulse and a burst of sine-waves.

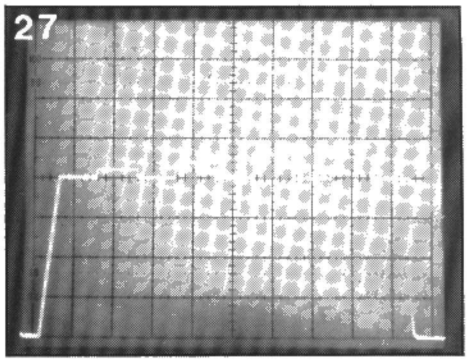


Fig. 27. This waveform, generated by the program in Fig. 29. shows the simulation of rectangular overvoltage pulses superimposed on the supply output voltage.

I<CR> = I00.00<CR> = 0 A
I.02<CR> = I00.02<CR> = 20 mA
I.25<CR> = I00.25<CR> = 250 mA
I2.50<CR> = I02.50<CR> = 2.5 A
Again, an example of a mistake:
I2.5<CR> = I00.25<CR> = 250 mA, not 2.5 A.

Host computer reads supply parameters:

u<CR>
Read set output voltage. Unit returned: volts, closed off by <CR>.
Example:
Host sends: u<CR>
Supply answers: 02.30<CR>

v<CR>
Read actual output voltage. Unit returned: volts, closed off by <CR>.
Example:
Host sends: v<CR>
supply answers: 02.10<CR>

i<CR>
Read set output current limit. Unit returned: ampères, closed off by <CR>.
Example:
Host sends: i<CR>
Supply answers: 02.50<CR>

j<CR>
Read actual output current. Unit returned: ampères, closed off by <CR>.
Example:
Host sends: j<CR>
supply answers: 01.00<CR>

Note: when ECHO is ON, the supply returns the command sequence. For the sake of clarity, echoed characters are not shown in the above examples.

Commands for mode setting

A<CR>
Selects slow (0.5 s) rate of change (slope) of the output voltage following a change in the set value. LED SLOPE on the front panel lights.

B<CR>
Selects fast rate of change (slope) of the output voltage following a change in the set value. LED SLOPE on the front panel goes out.

C<CR>
Enable the 0 V OUT function (if this had not been enabled previously). LED 0 V OUT lights if it was off.

D<CR>
Disable the 0 V OUT function if this was previously enabled. LED 0 V OUT goes out if it was on.

N<CR>
Select function NO LOCAL. Inhibits all front panel controls until the supply is reset, switched off and on, or until the reception of command LOCAL (L) or RESET (R).
When the supply is in the NO LOCAL mode, LED REMOTE CONTROL remains on after reception of the odd-numbered byte corresponding to the identification code — this is so arranged to provide an indication that the front panel controls are 'locked'. The LED goes out when either one of the above mentioned reset conditions is met.

L<CR>
Select function LOCAL. Enables front panel controls. The supply defaults to LOCAL after power-up.

X<CR>
Selects ECHO ON mode. Particularly useful when the supply is controlled by means of a terminal, or a computer acting as a terminal.

Y<CR>
Selects ECHO OFF mode (default after power-up). ECHO is best turned off when the host computer executes a program that controls instruments on the bus. ECHO is effectively turned off **after** the command itself, Y<CR>, has been echoed. Neither the question mark (syntax or transmission error) nor the oblique (HOLD mode) is echoed.

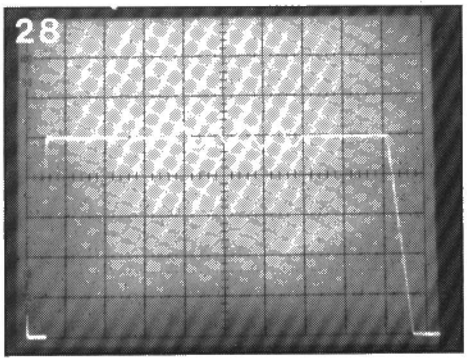


Fig. 28. A single rectangular pulse and four sine-wave periods as programmed 'ripple' on the supply output. The program that generates this waveform is listed in Fig. 29.

```
10 REM *********** TEST PROGRAM 'SINE-WAVE/PULSE' ***********
20 CLS
30 :
40 REM close files that are open
50  CLOSE
60 :
70 REM open communication port 'COM1:' (9600Bd, no parity, 8 bits, 2 stopbits)
80 REM as file number 1
90  OPEN "com1:9600,n,8,2" AS 1
100 :
110 REM delay (min. 0.2 s) to get correct interface voltage
120   FOR DELAY=0 TO 1000: NEXT
130 :
140 GOSUB 5000:                             REM initialize and close all devices
150 :
160 :
170 REM ************ MAIN PROGRAM **************
180 :
190 PI=3.141593
200 :
210 ADDRESS=132: GOSUB 1000:                REM open device 'ADDRESS'
220 :
230 REM initial settings
240   COMMAND$="I": VALUE=.5: GOSUB 4000:   REM I=0.5A
250   COMMAND$="U": VALUE=0: GOSUB 4000:    REM U=0V
260   COMMAND$="D": GOSUB 4000:             REM no 0V-out
270 :
280 REM start test cycle
290   COMMAND$="B": GOSUB 4000:             REM set fast slope
300 REM for 2 s: U=5V
310   COMMAND$="U": VALUE=5: GOSUB 4000:    REM U=5V
320   TIME=TIMER: WHILE TIMER-TIME<2:WEND:  REM delay 2 s.
330 REM for 0.1s: 5.5V (pulse)
340   COMMAND$="U": VALUE=5.5: GOSUB 4000:  REM U=5.5V
350   TIME=TIMER: WHILE TIMER-TIME<.1:WEND: REM delay 0.1 s.
360 REM for 1 s.: U=5V
370   COMMAND$="U": VALUE=5: GOSUB 4000:    REM U=5V
380   TIME=TIMER: WHILE TIMER-TIME<1:WEND:  REM delay 1 s.
390 REM four sine-wave cycles with ripple 0.5Vp-p
400   XMAX=100
410   FOR X=0 TO XMAX
420     COMMAND$="U": VALUE=5+.25*SIN(4*(X/XMAX)*2*PI): GOSUB 4000
430     NEXT X
440 REM for 2 s.: U=5V
450   COMMAND$="U": VALUE=5: GOSUB 4000:    REM U=5V
460   TIME=TIMER: WHILE TIMER-TIME<2:WEND:  REM delay 2 s.
470 REM return to 0V in 0.5 s.
480   COMMAND$="A": GOSUB 4000:             REM set slow slope
490   COMMAND$="U": VALUE=0: GOSUB 4000:    REM U=0V
500 REM stop, close device
510   GOSUB 2000:                           REM close device 'ADDRESS'
520 END
```

Fig. 29. Sample BASIC program that causes the microcontroller-driven power supply to generate (simulate) overvoltage pulses.

Make good use of the commands

It is recommended to make a habit of sending a CR after each command, as well as after the identification (instrument selection) code. This is particularly important during relatively complex programming situations, for instance, after a program interruption, or when a number of instruments are used simultaneously: it then often happens that one of these is not needed, but is still 'on line' and responds to commands intended for another instrument.

Select the NO LOCAL mode when the computer runs a program that causes it to communicate with the supply — it is then best to have the front panel controls 'locked' to prevent them being operated accidentally.

After each change in the set value of current or voltage, it is recommended to program a delay of about 0.5 s to ensure that measured values, read back with the aid of instructions **v** or **j**, are stable and valid.

In the same context, when the supply is controlled by a program written in assembly (or compiler) language, include a delay of at least 1 ms after instruction **R<CR>** (RESET) to allow the circuits, and in particular the serial interface, to be reset properly.

Still on the subject of timing, but in this instance referring to hardware: allow a software delay of 1 ms minimum between subsequent NUL commands (status request), to ensure that the TxD line can actually go sufficiently low (remember that TxD is effectively positive for about 90% of the time).

Sample programs

Having explained the operation of the hardware and external software control of the microcontroller-driven power supply, it is time to say something about the making of one of the most esential, yet least tangible, aspects of the design: the control program in the 8751. The 4 Kbytes of code in this are copy-protected to ensure some return of the investment of many hours of programming, testing and debugging in our laboratory.

The design of what can safely be called the most advanced power supply ever published by an electronics magazine has been made possible by our advanced 8751 emulator system from Intel.

Figure 25 illustrates the use of the programming language PL/M on this system by showing the display routines developed for the power supply.

The design itself is neither a worked-over application note, nor an adapted version of a (rejected or successful) commercial piece of equipment. It should also be emphasized that it is not an amateurish project of doubtful reproducibility for assembly in a couple of evenings. The publication in this magazine of the microcontroller-driven power supply is the direct and carefully planned outcome of numerous readers' requests for such a design.

The three BASIC programmes in this article (Figs. 26, 29 and 30) are intended as a guide to writing one's own control software for the intelligent power supply. The voltage waveforms generated by the programs of Figs. 26 and 29 are shown in Figs. 27 and 28 respectively.

The sample programs have been written in GWBASIC for use on IBM PC-XT/AT machines and compatibles. All routines work with ECHO OFF. Comment (REM) lines are provided to aid in analysing the function of the commands and lines. Also, the use of the CANCEL and IDENTIFY commands is illustrated, as well as a convenient way of sending the parameters for commands U and I with the aid of BASIC instruction PRINT USING.

Advantages of computer control

The serial interface on the power supply enables setting the output voltage in 10 mV steps, which is not possible by means of manual control because that would require 125 (or 83) encoder revolutions for the full 0 to 30 V range. For manual control, the step sizes are as follows:

U_o = 0 to 1 V: 20 mV

U_o = 1 to 10 V: 50 mV

30

```
1000 REM ********* OPEN DEVICE 'ADDRESS' ************
1010 REM
1020  PRINT#1,CHR$(ADDRESS);:        REM [ADDRESS]: open device 'ADDRESS'
1030 RETURN
1040 :
1050 :
2000 REM ********* CLOSE DEVICE 'ADDRESS' ************
2010 REM
2020  PRINT#1,CHR$(ADDRESS+1);:      REM [ADDRESS+1]: close device 'ADDRESS'
2030 RETURN
2040 :
2050 :
3000 REM ********* GET STATUS ***********
3010 REM
3020  PRINT#1,CHR$(0);: STATUS=ASC(INPUT$(1,#1))
3030 RETURN
3040 :
3050 :
4000 REM ********* OUTPUT COMMAND ***********
4010 REM
4020  GOSUB 3000:                         REM get status
4030  WHILE (STATUS AND 4)=0: GOSUB 3000:  REM loop if status flags "not ready"
4040   WEND
4050 REM ------------------------------------------------------------------
4060 REM Lines 4050-4170 are optional; if it is sure that remote control
4070 REM of all devices is enabled (=HOLD-LED is off), these lines can
4080 REM be left out of this subroutine.
4090  WHILE (STATUS AND 2)=0:              REM loop if remote-ctrl is disabled
4100   BEEP: CLS: PRINT "Remote control of device "; ADDRESS;" is disabled, ";
4110   PRINT "enable it (HOLD-LED must be off).":PRINT:PRINT "PRESS ANY KEY.":
4120   WHILE INKEY$="":                    REM wait for key
4130    WEND
4140  REM output <CANCEL> to make sure that command buffer of device is cleared
4150   PRINT#1,CHR$(&H18);
4160   GOSUB 3000:                         REM get status
4170   WEND
4180 REM ------------------------------------------------------------------
4190 REM output command (without <CR>!)
4200  PRINT#1,COMMAND$;
4210 REM if assignment command, output value (without <CR>!)
4220  IF (COMMAND$="U") OR (COMMAND$="I") THEN PRINT#1,USING"##.##";VALUE;
4230 REM output <CR>
4240  PRINT#1,CHR$(&HD);
4250 RETURN
4260 :
4270 :
5000 REM ********* INITIALIZE AND CLOSE ALL DEVICES ************
5010 REM This subroutine is only needed if you want to test which devices
5020 REM are responding (= connected to host and switched on).
5030 REM Leaving this subroutine closes and initializes all devices.
5040 REM
5050  PRINT "Addresse(s) of device(s) found: ";:   REM screen message
5060  FOR ADDRESS=128 TO 254 STEP 2
5070   GOSUB 1000:                   REM [ADDRESS]: try to open device 'ADDRESS'
5080   PRINT#1,CHR$(1);:             REM [1]: try to get address message
5090   FOR DELAY=0 TO 100: NEXT:     REM allow device some time to respond
5100   REM clear host RxD-buffer and get address (when returned) in 'DUMMY$'
5110    DUMMY$="": WHILE NOT(EOF(1)): DUMMY$=INPUT$(1,#1): WEND
5120   REM no or incorrect response? try next device
5130    IF LEN(DUMMY$)=0 GOTO 5190:             REM IF no response GOTO
5140    IF ASC(DUMMY$)<>ADDRESS GOTO 5190:      REM IF wrong response GOTO
5150     PRINT ADDRESS;:             REM screen message
5160     PRINT#1,CHR$(&H18);:        REM <CANCEL>: clear device command buffer
5170     COMMAND$="R": GOSUB 4000:   REM 'R': reset device 'ADDRESS'
5180     WHILE NOT(EOF(1)): DUMMY$=INPUT$(1,#1): WEND: REM clear host RxD-buffer
5190  NEXT ADDRESS
5200 RETURN
```

Fig. 30. Subroutines used by the programs of Figs. 26 and 29.

31

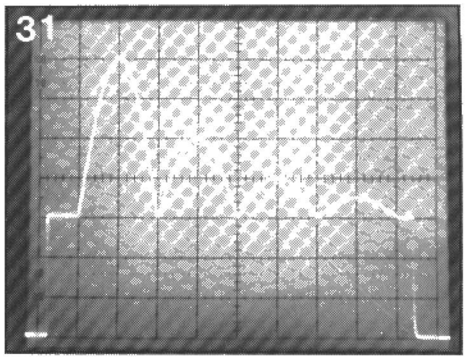


Fig. 31. A further example of the supply being programmed to simulate slow voltage transients.

U_o = 10 to 30 V: 100 mV

A similar arrangement applies to the control of the current, which can be set in 10 mA steps via the serial interface, against the following range-dependent values for manual control:

I_o<0.5 A: 10 mA

I_o>0.5 A: 20 mA

Initially, these differences in step size can give rise to unexpected situations. For example, it is not normally possible to set the supply to 1.03 or 1.08 V by means of manual control. But when the serial interface is used to program 1.03 V, it becomes possible to set 1.08 V by manual control, since the step size in the relevant range is 50 mV. An output voltage of 1.00 V can not be set manually then, however, unless one of the voltage switching thresholds is exceeded (1 or 10 V), or when 0 or 30 V is reached.

A few points are worth noting on the slow rate of change of the output voltage (slow slope). In principle, switching always takes 0.5 ±20% seconds with 'slow slope' activated. The relatively loose tolerance on the timing is due mainly to the algorithm used for calculating the slope steepness. Unfortunately, with voltages lower than 1 V, this algorithm is unable to yield a fixed timing of the slope. This shortcoming arises from the necessity to use whole numbers (integers). In order to ensure satisfactory results, the algorithm is structured such that a slope consists of a minimum of 100, and a maximum of 500, steps, while any single step has a minimum and maximum duration of 1 and 5 ms respectively. This means that the step size is not fixed, but bound to a minimum of 10 mV, which, in combination with the minimum step duration, causes the slope duration to be less than 0.5 s for voltage changes smaller than 1 V.

An example might help here to illustrate the above. Assuming the smallest step size is used, a voltage change of, say, 0.5 V would require 0.5/0.01=50 steps, forcing the algorithm to let go of the minimum of 100 steps. The slope duration is then the product of the number of steps and the maximum step duration, i.e., 50×0.005=0.25 s.

Conclusion

The description of the way in which the microcontroller-driven power supply can become part of a computer-controlled test and measurement set-up forms the conclusion of a three-part article. The staff of *Elektor Electronics* would like to hear of users' findings with the instrument, and welcome reports of practical applications.

At the end of this article we remind potential constructors of the supply to turn to the Readers Services page in this issue for our special offer of the complete set of PCBs and the front panel.
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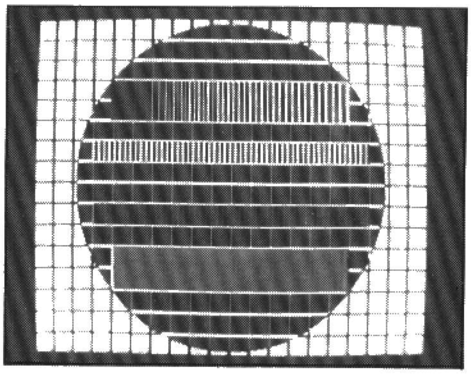

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The REM (remark) lines in the listing explain the operation of the program. The colour can be changed by pressing the Z or W key on the keyboard.

```
   1 REM ***** COMPUTER-GENERATED TEST CHART FOR BBC-B AND ELECTRON ****
   2 REM #####################  ELEKTOR ELECTRONICS #####################
  10 MODE7
  20 PRINT"Black can be changed to colour by pressing the Z key"
  30 PRINT
  40 PRINT"White can be changed to colour by pressing the W-key"
  50 PRINT:PRINT"But not before the test chart is complete"
  60 PRINT:PRINT"            PRESS THE SPACEBAR TO BEGIN...."
  70 REPEAT
  80 UNTIL INKEY(-99)
  90 REM --- Interlace OFF ---
 100 *TV0,1
 110 MODE0
 120 VDU 23,1,0;0;0;0;:REM --- Cursor OFF ---
 130 W%=7:Z%=0
 140 PROCcolour
 150 PROCvert
 160 PROChor
 170 R%=500
 180 PROCcircle
 190 X%=256
 200 lim=1
 210 FOR n%=0 TO 255
 220   PROCbandwd(7,0,704,127)
 230 NEXT
 240 X%=192
 250 lim=4
 260 FOR n%=0 TO 98
 270   PROCbandwd(0,7,576,63)
 280 NEXT
 290 X%=192
 300 lim=8
 310 FOR n%=0 TO 52
 320   PROCbandwd(7,0,384,63)
 330 NEXT
 340 X%=256
 350 FOR lim=12 TO 2 STEP -.185
 360   PROCbandwd(0,7,192,127)
 370 NEXT
 380 REPEAT
 390   IF INKEY(-98) THEN Z%=Z%+1
 400   IF Z%>=8 THEN Z%=0
 410   IF Z%=W% THEN Z%=Z%+1:REM -- foreground colour <> background! --
 420   PROCcolour
 430   IF INKEY(-34) THEN W%=W%+1
 440   IF W%>=8 THEN W%=0
 450   IF W%=Z% THEN W%=W%+1:REM -- background <> foreground! --
 460   PROCcolour
 470   IF INKEY(-113) THEN 1230
 480 UNTIL FALSE
 500 REM --- draws and fills circle ---
 510 REM --- within circle, colour is inverted per dot ---
 530 DEFPROCcircle
 540 PLOT4,640-R%,512
 550 FOR X%=-R% TO R% STEP 2
 560   Y%=SQR(R%*R%-X%*X%)
 570   x%=X%+640
 580   y%=Y%+512
 590   v%=512-Y%
 600   GCOL3,POINT(x%,y%)
 610   PLOT4,x%,y%
 620   PLOT5,x%,y%
 630   GCOL4,POINT(x%,v%)
 640   PLOT5,x%,v%
 650 NEXT
 660 ENDPROC
 680 REM --- draws vertical lines; width is 2 picture lines  ---
 700 DEFPROCvert
 710 x%=62
 720 REPEAT
 730   FOR a%=0 TO 4 STEP 2
 740     PLOT4,x%+a%,0
 750     PLOT5,x%+a%,1023
 760   NEXT
 770   x%=x%+64
 780 UNTIL x%>1280
 790 ENDPROC
 810 REM --- draws horizontal lines; width is 2 picture lines ---
 830 DEFPROChor
 840 y%=62
 850 REPEAT
 860   FOR a%=0 TO 4 STEP 2
 870     PLOT4,0,y%+a%
 880     PLOT5,1280,y%+a%
 890   NEXT
 900   y%=y%+64
 910 UNTIL y%>1024
 920 ENDPROC
 940 REM --- draws vertical lines at height Y% ---
 950 REM --- line width is function of h% and lim%. ---
 960 REM --- In logic colours col1% en col2% ---
 980 DEFPROCbandwd(col1%,col2%,Y%,h%)
 990 GCOL0,col1%
1000 PROCblock
1010 GCOL0,col2%
1020 PROCblock
1030 X%=X%+1
1040 ENDPROC
1050 DEFPROCblock
1060 FOR a%=0 TO lim
1070   PLOT4,X%+a%,Y%
1080   PLOT5,X%+a%,Y%+h%
1090   x%=X%+a%
1100 NEXT
1110 X%=x%
1120 ENDPROC
1140 REM --- switching from logic colours to real colours ---
1150 REM --- timed by vertical sync. ---
1160 REM --- Only two colours can be displayed simultaneously ---
1170 DEFPROCcolour
1180 *FX19
1190 VDU19,0,W%,0,0,0
1200 *FX19
1210 VDU19,7,Z%,0,0,0
1220 ENDPROC
1230 VDU23,1,1;0;0;0:REM --- Cursor ON ---
1240 CLS:END
>
```

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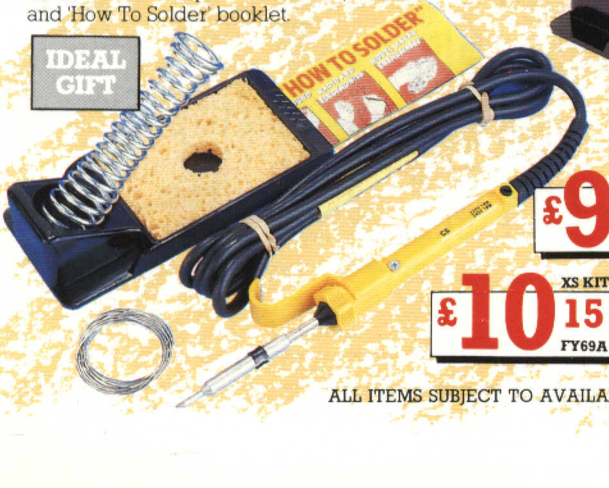

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